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WEEKLY NEWS IDEAS INNOVATION

NewScientist

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**SPECIAL
EDITION**



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Vaccines for pennies
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Forging a superpower p 30

ON THE COVER
 India special report, starts page 30
 Tracking gravity, page 54



More hints of Martian life p 6

NEWS

EDITORIAL

Pharming is fine, but don't do it
 with food crops **3**

UPFRONT

North Korea admits to nuclear weapons;
 Ariane 5 heavy rocket launched; Crick's
 first DNA scribble; Kyoto – at last; does
 politics rule science at US agency? Fears
 over new HIV strain **4**

THIS WEEK

Martian life debate ignites again **6**
 IVF problems due to growth medium? **7**
 Make bird flu vaccine now, says WHO **8**
 Galactic dust could trigger deep ice age **9**
 Giant lightning seeded planets **12**
 Privatisation raises nuclear safety fears **13**
 Phones blamed for sperm damage **13**
 Dino-bird clues to early flight **14**
 Hearing restored in deaf animals **15**
 Evolution rerun – what do you get? **16**
 The healing **16**

IN BRIEF

Oldest human fossils; recovering forest is
 pale imitation; language is not essential
 for arithmetic; Earth telescopes measure
 winds on Titan; next Vesuvius eruption
 may not be so explosive; mosquito
 eaters help beat dengue; St John's wort
 is as good as prescription drug; vaccine
 potatoes get the chop **18**

TECHNOLOGY

New chip on the block **23**
 Nanotubes clean up water **24**
 GPS-guided trains **25**

TRENDS: INTERNET PHONE CALLS

As broadband takes off, millions are
 falling for the lure of free phone calls **26**

REGULARS

COMMENT AND ANALYSIS

The artefacts of the internet era may not
 look like antiques, says Jeremy Norman,
 but they are still collectable treasures **20**

LETTERS

Heating Earth's crust; defending dyslexic
 drivers; saving gene banks; mine and
 yours in space; religious road safety **28**

POLITICS

Antipodes **21**

ENIGMA

21

FEEDBACK

64

THE LAST WORD

65

JOBS

58

FEATURES

COVER STORY – INDIA SPECIAL

THE NEXT KNOWLEDGE SUPERPOWER
 Make no mistake, India is heading for
 greatness. *New Scientist* investigates a
 world-beating nation in the making **30**

GOING IT ALONE

Blasting off despite tough sanctions **33**

BY THE PEOPLE, FOR THE PEOPLE

Home-grown genetic modification **36**

SILICON SUBCONTINENT

A new home for high-tech research **38**

RIGHT HERE, RIGHT NOW

India's young IT crowd has it all **40**

MAKE IT PAY

Science has to make economic sense **41**

VACCINES FOR PENNIES

The bankers said it couldn't be done **42**

DISHES TO SAVOUR

Why astronomers love wine country **43**

VOYAGE OF DISCOVERY

High stakes for drug companies **44**

'WE HAVE TO TAKE RISKS'

Interview with Shobo Bhattacharya **47**

DARING TO BE DIFFERENT

Bold plans for a nuclear future **48**

SIGHT FOR SORE EYES

Pioneering treatment for blindness **50**

REINVENTING INDIA

How to grow a billion-dollar firm **52**

WELCOME TO THE GLOBAL VILLAGE

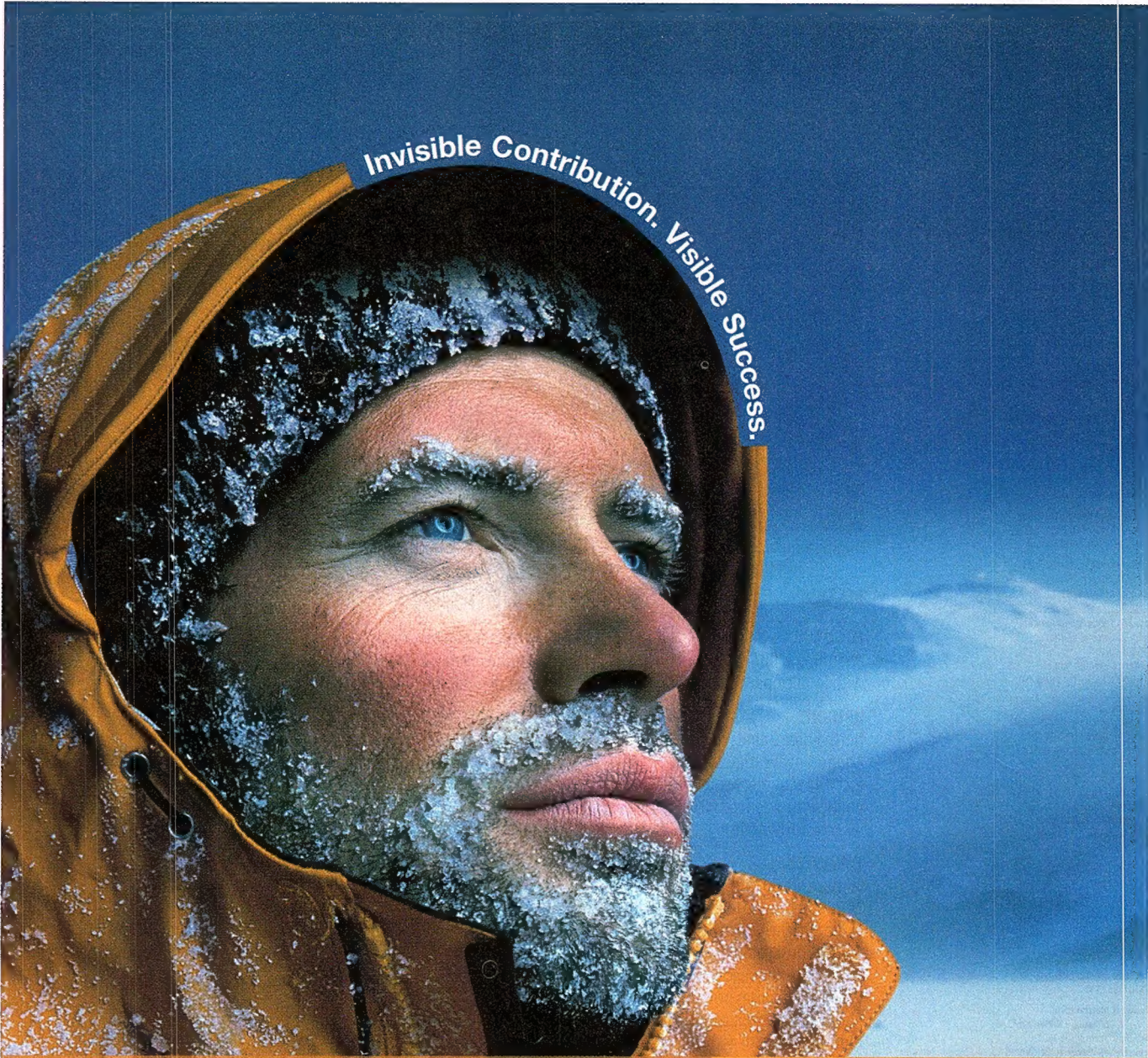
Where the internet meets rural India **53**

PLUS: ENLIGHTENMENT

The mystery of missing gravity is
 leading us to a higher plane... **54**

**"The recovery of the hair cells brought the
 treated ears to between 50 and 80 per cent
 of their original hearing thresholds"**

What gene therapy could do for hearing loss, page 15



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Too tempting

There is just one problem with edible vaccines

SOME ideas, no matter how good they look on paper, should never be tried in practice. One of these is the notion of producing drugs or vaccines in genetically engineered food crops. Why? Because the risk of these potent chemicals finding their way into the human food chain is just too high.

So we are pleased to note the decision by one of the world's authorities on "pharming", as this idea is called, to replace food crops with a relative of the tobacco plant. Charles Arntzen of Arizona State University is a pioneer of edible vaccines: foods that are genetically engineered to contain a vaccine. However, fears that the modified crop – or the altered gene within it – could find its way into the food of unsuspecting people have convinced Arntzen to think again. He has devised a different model for making edible vaccines (see page 19).

Using food crops is risky for several reasons. Pollen containing the gene may fertilise strains of the crop intended for the table. Seeds from a pharm crop left in the field after harvesting may grow the following season, something that has already happened when GM corn plants came up in soybean plots in Iowa and Nebraska. If harvested crops are not properly segregated, modified versions could easily get

mixed up with food crops. This too has happened before, when Starlink, a variety of GM corn meant only for animal feed, turned up in foods across the US. Then there is theft, which has also taken place. In China, researchers from Beijing University buried a batch of experimental GM tomatoes to prevent their seeds spreading. But local farmers dug up the fruit and ate them or planted the seed.

There are ways to limit some of these risks, such as engineering modified plants to be sterile. But the only foolproof way to prevent accidents is not to use food plants at all. Agribiotech companies will complain that food crops grow fast, produce lots of protein and are what they know most about. But these are poor excuses. Breeding a few fast-growing high-yielding non-food crops and getting to know their genomes would be a small price to pay for public confidence.

One other argument used by agribiotech companies to defend their corner is that even if a protein from a drug or vaccine did get into the food chain it would be destroyed in the human gut. Arntzen's work with potatoes modified to produce a hepatitis B protein casts doubt on this, too. More than half the people who ate the potato produced large numbers of antibodies to hepatitis B. Why take the risk? ●

Polio down but not out

A SECOND case of polio reported in Saudi Arabia has not dented the confidence of officials at the World Health Organization that it can eradicate the virus this year. Saudi Arabia, which has a high vaccination rate and good sanitation, had been free of the disease since 1995. Both cases, which were identified late last year, look as though they were imported from Africa.

In Africa polio is endemic in only three countries: Egypt, Niger and Nigeria. But over the past 18 months, travellers from these countries have re-infected 12 previously "clean" nations, including Chad, Cote d'Ivoire and Sudan. Last year, the virus reached Port Sudan on the Red Sea, the main crossing point for people travelling to Mecca for the annual pilgrimage or hajj. This led to fears that the virus might spread widely during this year's hajj, but so far no other suspected cases of

polio have been reported from Saudi Arabia.

Mopping up polio has been hampered in many African countries by problems ranging from war to a rumour in the Nigerian state of Kano that vaccine had been contaminated. This month the WHO will embark on its largest vaccination campaign in Africa, aiming to immunise 80 million children in 22 countries in one week. Efforts to wipe out the virus in the three other countries where polio is endemic – India, Afghanistan and Pakistan – went well last year: the number of cases fell by 45 per cent to 186.

The cases in Saudi Arabia serve to emphasise that no country is properly polio-free until all nations are. The WHO's polio eradication campaign is short of \$75 million for continued vaccination later this year. To get so close to eradication and falter at the last step would be nothing short of criminal. ●



Why did an expert on the Florida panther lose his job?

Workhorse Derby

IN THE race to develop a heavy-lifting rocket, Europe has nosed ahead with the successful launch on 12 February of its Ariane 5 Heavy booster. This follows the disastrous first attempt two years ago, when the rocket veered off course and had to be destroyed.

In December, Boeing's Delta 4 Heavy rocket succeeded in reaching space, but its engines shut down prematurely and the test satellites it carried fell short of their intended orbits. Boeing might attempt a second launch in mid-2005.

The Ariane 5, launched from the Kourou space port in French Guiana, carried XTAR-EUR, the first commercial communications satellite to operate in the microwave X band, plus a European Space Agency instrument called MAQSAT designed to measure rocket performance. Also on board was

an ESA microsatellite dubbed Sloshtat – a tank partly filled with water to study the sloshing of liquids in space.

The launch puts Europe slightly ahead of US in the race to place 10-tonne satellites in geosynchronous orbit. The Ariane 5 Heavy is capable of lifting 9.6 tonnes 36,000 kilometres into space. The standard Ariane 5 on which it is based can only manage 6.7 tonnes. The heavy version can carry two communications satellites into orbit rather than just one, lowering the launch cost per satellite.

First impressions

THE first rough pencil sketch of a DNA molecule by the late Francis Crick was made available online for the first time on Monday. The scribble, along with an archive of his work, will give a unique insight into the discovery of the legendary double helix.

The 1953 breakthrough heralded a new era of genetic science and earned Crick and James Watson a share of the 1962 Nobel prize for medicine.

SCIENTISTS FEEL POLITICAL HEAT

Critics of the Bush administration have long accused it of putting ideology before evidence. Now a survey of government scientists appears to confirm that science plays second fiddle to politics in at least one government agency.

Half the scientists from the US Fish and Wildlife Service (FWS) who responded to the survey said they had been pushed to alter or withdraw scientific findings relating to species protection for political reasons. Around a third said they were not allowed to do their job as scientists.

"Political interference with science at the FWS has become pervasive," says Lexi Shultz at the Union of Concerned Scientists in Washington DC, which produced the report with Public Employees for Environmental Responsibility (PEER), a DC-based group that represents government whistle-blowers. "We think this is a very widespread problem. We

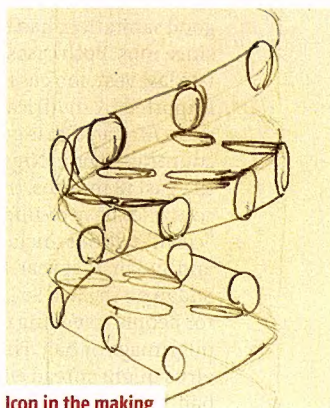
don't think this is isolated to the FWS."

Around 400 of the 1400 scientists at the FWS responded to the survey, and 42 per cent of these said they could not openly express concerns outside the agency for "fear of retaliation". Nearly a third felt they could not do this even within the confines of the FWS.

One high-profile case may have contributed to their fears. Andy Eller, an FWS expert on the Florida panther, publicly accused his employers of knowingly using out-of-date science in decisions on whether to allow development that might impinge on the panther. "What's going on in Florida is a huge development boom," says Jeff Ruch, an employment lawyer with PEER. "The FWS is doing its best to get out of the way of that." Eller was sacked in November. The FWS says this was because he missed performance targets. He says it was because he spoke out.

"This scribble and the rest of the archive give a unique insight into DNA's discovery"

Crick's doodle is one of 350 documents and images posted online by the Wellcome Trust, some from Crick's personal archive, including his original research papers on DNA and genetic codes. The hope is that the finished archive compiled with the help of US National Library of Medicine will contain 11,000 items. It can be viewed at <http://profiles.nlm.nih.gov>.



Icon in the making

Climate respite?

THE world is cooling, according to figures published by NASA on 10 February. Last year was cooler than 2003, which was cooler than 2002. And 1998 was warmer than all three.

Does that mean the Kyoto protocol, which came into force on Wednesday, is as redundant as climate sceptics say? It does not. Barring short-term variation, global temperatures are rising inexorably. 1998, 2002, 2003 and 2004 were the hottest years on record. Nine of the 10 hottest years have been in the past decade. And global temperatures have already risen almost a quarter of a degree since the Kyoto protocol was signed in 1997.

The agreement has been ratified by 141 countries, although the US and Australia are still conspicuous by their absence. And it seems the actions it requires of industrialised nations to cut carbon emissions are needed more than ever. As the NASA figures were announced, Jim Hansen, director of the agency's Goddard Institute for

Space Studies and the US government's top climate scientist, said that a continuing underlying trend of warming, coupled with a mild El Niño, is likely to put 2005 on a par with 1998, the hottest on record.

Target the kids

OUR strategy for flu vaccination is all wrong, a series of studies suggests. Instead of targeting elderly people, health agencies might prevent more deaths by vaccinating as many children as possible.

A study by Lone Simonsen of the US National Institute of Allergy and Infectious Disease concludes that flu vaccination makes little difference when it comes to saving the lives of elderly people. Her team found no change in the winter death rate of elderly people between 1980 and 2001, even though the number given flu vaccination jumped from 15 to 65 per cent during this period, they report in this week's *Archives of Internal Medicine*.

This may be because flu vaccine induces less immunity as people get older, or because the oldest and frailest people, who are most likely to die of flu, are least likely to be vaccinated.

Vaccinating children instead might make more sense,

"Vaccinating a fifth of children prevented nearly a fifth of infections in adults"

according to two other studies, at Emory University in Atlanta, Georgia, and Baylor College of Medicine in Houston, Texas. The Baylor group found that vaccinating a fifth of children in a community also prevented nearly a fifth of respiratory infections in adults, while the Emory group's mathematical model suggests that vaccinating 60 per cent of US schoolchildren might cut flu deaths among over-65s by 80 per cent.

Super-HIV scare

A SINGLE HIV case in New York has raised fears of a new strain that is both highly resistant to drugs and causes rapid onset of AIDS.

The strain infecting a man in his forties has turned out to be resistant to 19 of the 20 licensed anti-retroviral drugs. The man also developed AIDS within two to 20 months of infection, whereas it normally takes more than 10 years. Some HIV strains have one or other of these properties, but no known strain has both.

It is too early to tell if this really is a new "super-strain". The man used the amphetamine "crystal meth", which might have weakened his immune

"Some HIV strains have one or other of these properties, but no known strain has both"

system. Or his genetic make-up may have made him particularly vulnerable. If it is a new strain, it may not have been passed on to other people.

"This patient's infection with an HIV-1 strain not amenable to standard anti-retroviral therapy, along with his rapid clinical and immunological deterioration, is alarming," says David Ho, head of the Aaron Diamond AIDS Research Center in New York, which is investigating the case. "While this remains a single case, it is prudent to closely watch for any additional possible cases."

NORTH KOREA'S NUCLEAR BOAST

North Korea has declared it has nuclear weapons. A statement issued through the Korean Central News Agency on 10 February said US hostility had forced the country to "bolster its nuclear weapons arsenal".

Since withdrawing from the Nuclear Non-proliferation Treaty in 2003, North Korea has often referred to its capacity for nuclear deterrence, but this is the first time it has said explicitly it has nuclear weapons. It probably has enough fissile material to make between five and ten bombs, according

to the Center for Nonproliferation Studies (CNS) in Monterey, California.

North Korea also withdrew from the "six-nation" talks that included the US and Russia. The US Secretary of State, Condoleezza Rice, who has previously labelled the country an "outpost of tyranny", said the North Koreans "are only deepening their isolation".

Daniel Pinkston, a specialist on North Korea at CNS, argues that the US can help by holding bilateral talks. "By ignoring the North Koreans you will not get cooperation in a million years."



Power struggle

60 SECONDS

Missed again

The US missile defence system failed its second test in two months. A missile meant to intercept a target rocket fired from Kodiak, Alaska, on Sunday did not get off its launch pad in the Marshall Islands in the central Pacific. The Pentagon is blaming ground equipment, not the missile. The target rocket fell into the sea.

Away with the dairies

Farmers in Liechtenstein will no longer be allowed to feed *Cannabis sativa* to their cows. Using hemp as fodder is a long-standing tradition in the Alpine state, a government spokesman told *New Scientist*. But it was banned after traces of THC, the active ingredient in cannabis, were found in milk.

Fatal dam burst

More than 100 people have drowned after a dam burst near Pasni in Pakistan. The 300-metre-wide irrigation dam, which blocked the seasonal Shadikor river, had no proper spillways to relieve pressure on the structure when the river was in spate. Local reports say a previous dam at the site was washed away in 2003.

Mad-cow test cut

President Bush's budget proposal for the next fiscal year will slash the number of US cattle tested for BSE by 80 per cent. Since June 2004, the US has tested more than 220,000 cattle. Three showed "inconclusive" results, and they were eventually declared negative. Under the new plan, due to start in October, only 40,000 per year will be tested.

Spray-on lust

Women with low libido can increase their sex drive by spraying testosterone on their skin, says Vivus of Mountain View, California, which has completed clinical trials of its experimental product. However, two of the 261 premenopausal women in the 28-week trial withdrew because the hormone was having an unwelcome side effect: a slight increase in hair growth.

This week



Bacteria in the soil?

A whiff of life on the Red Planet

Space scientists are gearing up for a heated debate over one man's conclusion that there must be life on Mars

JENNY HOGAN

A LEADING European Space Agency scientist says he has found a gas in the Martian atmosphere that he believes can only be explained by the presence of life. But the few researchers who have been privy to the facts say that such a conclusion is premature.

Vittorio Formisano of the Institute of Physics and Interplanetary Science in Rome

will be speaking next week at the first conference dedicated to the results from ESA's Mars Express spacecraft. The craft has been orbiting the Red Planet since December 2003. Agustin Chicarro, the project scientist for Mars Express and the organiser of the conference in Noordwijk, the Netherlands, says he expects sparks to fly. "We have allocated one full hour of debate – it could be a lively discussion."

Scientists are understandably cautious. The list of discredited claims for life on Mars is long: from canals built by intelligent beings that early astronomers thought they saw, to "bacteria fossils" found in a Martian meteorite that fell in Antarctica. The fossil-like structures, which were discovered in 1996, are now thought to have been etched by chemical processes.

The debate reignited last year when three teams, including one led by Formisano, independently detected methane on Mars – a gas that bacteria produce on Earth. Some speculated that similar microbes could be producing the methane on Mars. But others argued that methane at the observed concentrations could be explained by non-biological processes producing about 150 tonnes of methane per year. A

comet that crashed on Mars long ago or some kind of volcanic activity could supply that amount.

Now Formisano is saying that there is much more methane on Mars. He bases this on the detection of a different gas, formaldehyde, by the Planetary Fourier Spectrometer (PFS), an instrument on Mars Express that he runs. Formisano averaged thousands of measurements taken by the PFS and calculated that the Martian atmosphere has formaldehyde in concentrations of 130 parts per billion.

He thinks that the gas is being produced by the oxidation of methane and estimates that 2.5 million tonnes of methane per year are needed to produce it. "I believe that until it is demonstrated that non-biological processes can produce this, possibly the only way to produce so much methane is life," he says. "My conclusion is there must be life in the soil of Mars."

The presence of formaldehyde could explain why earlier studies found uneven distributions of methane on Mars, says Formisano. Because methane takes hundreds of years to break down by itself, the wind should

"I believe that until it is shown that non-biological processes can produce this methane, possibly the only way is life"

even out the concentration of the gas around the planet. But if it is being oxidised in some regions, such as those that are rich in iron compounds, then you would find less methane in those areas.

But other experts, including Formisano's collaborators on the PFS and other principal investigators on the Mars Express mission to whom Formisano has presented his work, advise caution. He may be alone in pursuing formaldehyde, says one of his collaborators, Sushil Atreya from the University of Michigan, Ann Arbor.

Others warn that Formisano is pushing the instrument to its

In this section

- Make bird flu vaccine now, says WHO, page 8
- Giant lightning seeded planets, page 12
- What happens when you rerun evolution, page 16

limit in trying to look for formaldehyde. To identify compounds, the PFS looks for dark absorption lines in the spectrum of light reflected from Mars. Formaldehyde absorbs a handful of infrared wavelengths, but the instrument is not sensitive enough to see the individual lines. "It is not 100 per cent convincing," says Therese Encrenaz, from the Paris Observatory, France, another of Formisano's colleagues. "But I think it deserves further work."

Even if Formisano has found formaldehyde, it is not necessarily coming from the oxidation of

"If this issue was a bit less controversial then maybe we'd be at the point of some kind of press conference"

methane. And even if there are large amounts of methane on the Red Planet, it might not be biological in origin.

"Frankly, we don't know what the internal geology of Mars is like. To draw conclusions on whether it is biological or not at this stage is damn risky," says Michael Mumma of NASA's Goddard Space Flight Centre in Greenbelt, Maryland, who last year found methane on Mars using Earth-based telescopes.

Formisano agrees that he has no conclusive proof. "I cannot demonstrate for sure," he says. "But these hints for life I have found are the best one can get. The next step is to go there and look for it." Future missions, such as NASA's Mars Science Laboratory now in the planning stage, will look for and analyse organic molecules in the soil.

While other evidence suggests that Mars was and may still be hospitable to life, ESA is playing it safe. "If this issue was a bit less controversial, then maybe we would be at the point of having some kind of press conference," says Chicarro. "But we need to leave the scientific community to its natural course and have it debated there." Debate at next week's conference is certain. ●

Are IVF embryos starved of a vital ingredient?

THE lack of natural growth factors in the fluid in which IVF embryos are grown could have lifelong effects on people conceived this way. That is the implication of a study on mice by Australian researchers, who say preliminary studies of human embryos back their claims.

Although the latest review of IVF safety found no differences between 8-year-olds conceived normally and those conceived by IVF or ICSI, the possibility of long-term health effects still cannot be ruled out. There are certainly differences early on: singleton babies conceived by IVF or ICSI are more likely to have a low birthweight and to die soon after birth (*New Scientist*, 23 October 2004, p 10).

Could these problems have something to do with the process of IVF or ICSI, such as growing the embryos in a dish for two to five days? Growth media have been developed by trial and error, and contain only a few amino acids and other nutrients. They have been kept simple in the hope of avoiding unanticipated effects.

Yet according to Sarah Robertson's team at the University of Adelaide, at least one growth factor is needed. Her team compared the fate of three groups of mouse embryos: embryos conceived naturally and flushed from the mother's body; IVF embryos grown in a normal culture medium; and IVF embryos grown in a medium containing a growth factor called GM-CSF, which a range of mammals produce, including humans.

The placentas of the mouse embryos grown without GM-CSF were smaller and the pups' birthweight lower compared with the embryos conceived naturally. By adulthood, these mice had grown fatter than the other mice, and the males also had smaller brains. Adding GM-CSF to the culture medium almost completely eliminated these differences, the team will report in the journal *Endocrinology*.

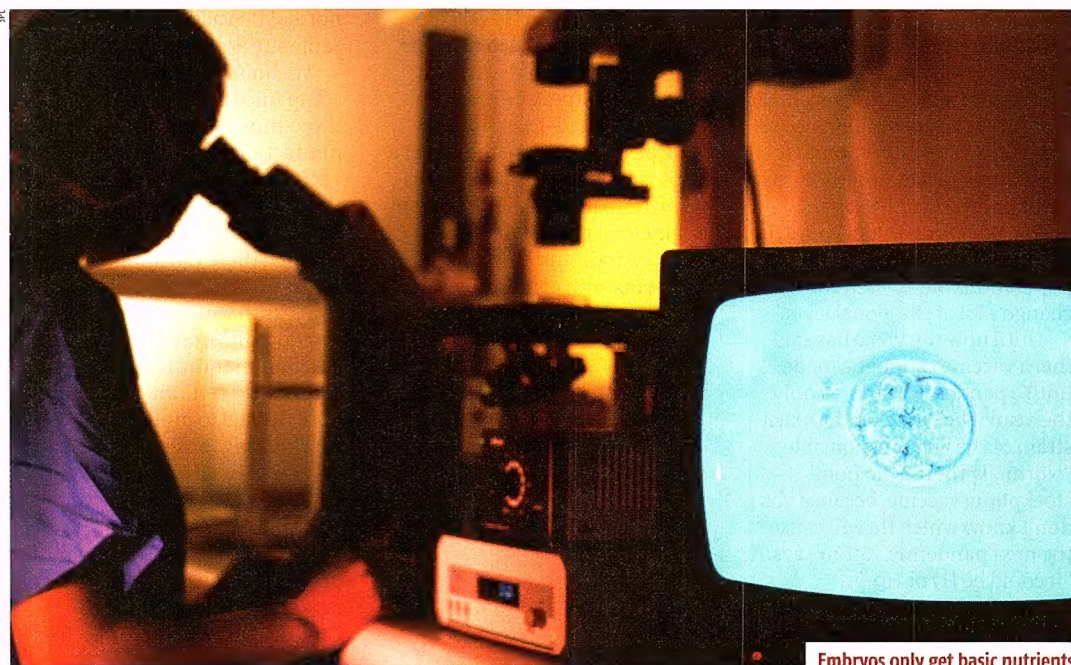
The differences between all groups were relatively small, cautions IVF expert Alan Handyside of the University of Leeds in the UK.

And even if the results do stand up, it is not clear if mouse studies are relevant to humans.

Barry Behr, director of the clinical IVF laboratory at Stanford University in California, thinks it is highly relevant. "I've always attributed the problems of IVF to the deficiencies of our culture medium." But Roger Gosden, director of research at the Center for Reproductive Medicine and Infertility in New York, is more cautious. "You have to be careful," he says. "There are substantial differences between species."

Robertson says preliminary studies show that GM-CSF more than doubles the chances of human embryos surviving to the blastocyst stage, from 35 to 75 per cent. She is working with a Danish company called Medicult on products containing GM-CSF.

But if GM-CSF increases survival by keeping abnormal embryos alive, it could increase the risk of health problems, Handyside points out. He thinks existing growth media do need improving. But he does not believe that experimenting with new components can be justified until researchers know exactly what effect these components have. "Without a scientific basis you cannot anticipate the effects," he says. "That is the bind we find ourselves in." Douglas Fox ●



Embryos only get basic nutrients

Stockpile bird flu vaccine now

DEBORA MACKENZIE

GOVERNMENTS should consider stockpiling vaccine against H5N1 bird flu now, before a pandemic starts, a World Health Organization report out next month will advise.

The change in policy reflects growing fears that an H5 pandemic is likely, and that there will not be time to produce much vaccine once it starts. "When we realised H5N1 is not going to be eradicated in poultry in Asia for at least another couple of years, that made the risk of H5 much higher," Klaus Stöhr, head of the WHO's influenza team, told *New Scientist*.

The US has already contracted manufacturers to make 4 million

"Normally there is no point stockpiling vaccine, but the persistence of H5N1 is changing minds"

doses, while at a meeting at WHO headquarters in Geneva last week Italy and France said they plan to stockpile 2 million doses each. But in a world of over 6 billion people that is nowhere near enough to make a significant difference, as Stöhr points out. "This is an option only for affluent countries, and then for a fraction of their population," he says. "It won't change a lot at the global level."

Until now the WHO has said that a vaccine cannot be made until a pandemic starts, as only then can it be based on the exact strain of the virus responsible. "Normally there is no point stockpiling vaccine, because you don't know which flu will cause the next pandemic," Stöhr says. "It could be H7 or H9."

But the failure to halt the H5N1 bird flu outbreaks in Asia, and the growing number of human cases

(see Table), is changing minds. Recent findings also suggest that a stockpiled vaccine could provide some protection even if it does not exactly match the pandemic virus. Experiments on animals at St Jude's Children's Hospital in Memphis, Tennessee, show that while previous exposure to similar strains may not stop them falling ill when infected with H5N1 flu, it can prevent them dying.

What's more, people normally require two shots of a vaccine to make them immune to a strain of flu they have not encountered before. An H5 vaccine would prime people's immune systems, so they would need only one shot of a specific pandemic vaccine. "My gut feeling is that if you're primed with H5, you'll respond better to the flu or to the real vaccine," says Tony Colegate of Chiron Vaccines in Liverpool, UK, who heads an international industry task force on pandemic flu.

Such evidence has persuaded the experts that an H5 vaccine might help. Now the problem is making it. So far, only half the planned US stockpile has been made, by Sanofi-Pasteur in the US. Chiron is to make the rest at a pilot factory in Liverpool that is licensed to handle the genetically engineered viruses required. But it cannot start until the problems with contamination that shut down the company's

CLEAR AND PRESENT DANGER

Confirmed human cases of avian influenza A since 28 January 2004

COUNTRY	NUMBER OF CASES	DEATHS
Cambodia	1	1
Thailand	17	12
Vietnam	37	29
TOTAL	55	42

SOURCE: WHO



Only one in four survive bird flu

normal flu vaccine plant at the same site are cleared up.

Without a dedicated factory, companies have only a two to three-month window between production runs of ordinary flu vaccine to make H5 vaccine. And they cannot even do that, Colegate says, unless someone will buy it.

Then there is testing. It is obviously impossible to find out in advance whether a vaccine will provide any protection against a pandemic strain. But it is possible to do safety tests and work out the dose needed to produce an immune response.

Clinical trials of limited batches of H5 vaccine, based on the strain now circulating in Asia, are about to start in the US and are planned in Canada, Australia and Japan, all with government funding. Because these vaccines have been made at different

plants using different production methods they must be tested separately. No European governments have pledged funding for clinical trials even though most of the world's flu vaccine is made in Europe.

Not everybody is convinced that spending money on testing and stockpiling an H5 vaccine is worthwhile. Albert Osterhaus of Erasmus University in Rotterdam, the Netherlands, thinks money would be better spent on stockpiling antiviral drugs, as the WHO has long recommended.

But the capacity for manufacturing antivirals is limited, and there is also no guarantee that existing drugs will work against a pandemic strain. Other leading experts think the threat is so serious that we should be doing everything we can to prepare. ●

SOUNDBITES

“Look at this. I’m a grocery item. I’m a piece of meat. I’m an orange.”

A 13-year-old girl at **Brittan Elementary School** in Sutter, California, outraged at being given an electronic tag to monitor her movements in school (*San Francisco Chronicle*, 10 February)

“They reacted like men faced with a large billboard of a lingerie model.”

Neurobiologist **Michael Platt** at Duke University in North Carolina, describing how male monkeys take a voluntary cut in their fruit juice allowance to look at pictures of female monkeys’ bottoms and high-status males (*The Observer*, London, 13 February)

“We don’t know if the three male pairs are really gay or just got together because of a lack of females.”

Heike Kück, director of Bremerhaven Zoo in northern Germany, on six male Humboldt penguins who have taken to trying to mate with each other and incubate stones as if they were eggs (*The Daily Telegraph*, London, 14 February)

“Women are fragile and delicate creatures; that is why men should lead the way to distant planets and carry women there in their strong hands.”

Anatoly Grigoryev, director of Moscow’s Institute of Medical and Biological Problems, explains the reasoning behind a decision not to select any women to take part in a simulated 500-day mission to Mars (Novosti – Russian news agency, 10 February)

“My darling, oh my darling. We will soon go home.”

A tearful **Junita Jeyarajah** on being reunited with her son Abilash after DNA tests confirmed his identity. The Sri Lankan child, nicknamed “baby 81”, was found in the rubble left by the Asian tsunami (news.com.au, 15 February)

Earth plunged into dust and came out icy white

AN ENCOUNTER with a cloud of interstellar gas could plunge our planet into a deep freeze that could drastically impact life on Earth. An event like this may have been what triggered “Snowball Earth” – a time when the entire planet was covered in snow and ice.

In 1992, Joe Kirschvink, a specialist in palaeomagnetism from California Institute of Technology in Pasadena coined the term “Snowball Earth” to describe such a big chill. A few years later, Harvard University geologists Paul Hoffman and Dan Schrag strongly supported Kirschvink’s idea and argued that Earth was completely sheathed in ice at least twice in its history – about 600 million and 750 million years ago. But the cause has remained a mystery.

Now Alex Pavlov of the University of Colorado, Boulder, and his colleagues say that interstellar gas could be the culprit. The Milky Way is laced with gigantic clouds of hydrogen, which are concentrated mainly in the galaxy’s spiral arms. As our solar system orbits the centre of the galaxy it passes in and out of these arms, encountering about eight such clouds in the 250 million years that it takes to complete an orbit.

The damage would be done by the sprinkling of carbon and silicate dust particles these clouds contain. The Earth’s atmosphere is normally protected from this dust by the pressure of the solar wind – a blast of hot ions streaming out from the sun. But around 1 in 30 of these gas clouds are dense enough to overpower the solar wind, allowing dust to pour into the Earth’s atmosphere, Pavlov says (*Geophysical Research Letters*, vol 82, p 3705).

The influx would block as much sunlight as the outpourings from three volcanic eruptions a year, and it would last a lot longer. “It takes 200,000 years to cross the cloud,” Pavlov says. The result would be a Snowball Earth. Though Hoffman was initially cool towards Pavlov’s

theory, he has quickly come round. “I can’t see anything wrong with this idea,” he says.

If dust did pour into the atmosphere, it might have left increased levels of uranium-235 in rocks. “It’s for geologists now to go and look,” Pavlov says. But Hoffman is not convinced that looking for uranium-235 is the right thing to do. “Uranium isotope ratios are easily altered in carbonate rocks,” he says. He hopes to devise other tests to verify Pavlov’s theory.

In 2002 Schrag and Pavlov independently came up with another possible trigger for Snowball Earth:

“The influx of dust would block as much sunlight as three volcanic eruptions a year, and it would last a lot longer”

a fall in levels of the greenhouse gas methane. But Pavlov now says it is difficult to explain how methane levels could have risen again.

“I would love it to be true, but it doesn’t work,” he says. Other explanations have also had trouble accounting for the abrupt change necessary to trigger a Snowball Earth.

While Earth will rarely encounter galactic clouds dense enough to trigger a global ice age, less dense clouds could also have a serious effect. By compressing the protective solar wind shell surrounding the solar system, they might allow galactic cosmic rays and hydrogen from the cloud to enter the atmosphere. This would destroy the Earth’s ozone layer and allow in ultraviolet-B radiation from the sun that would kill many species (*Geophysical Research Letters*, vol 82, p 1815).

Our last line of defence against this would be the Earth’s magnetic field, but this vanishes roughly every 200,000 years when the poles reverse. “It’s not as bad as a snowball but it would probably destroy a lot,” Pavlov says. Eugenie Samuel Reich ●



Dimmer sun, drastic results

PHIL GAUGE/MILLENNIUM

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Car shown is 2.5 litre V6 Sport with metallic paint, Aruba wheels.



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Once it spanned the solar system

Did Earth form in flash of galactic lightning?

GIANT lightning strikes that were triggered by gamma-rays could have led to the formation of meteorites and rocky planets such as Earth. The lightning spanned the early solar system and fused grains of dust into spheres that became the seeds for larger objects.

Meteorites that formed early in the history of the solar system are rich in chondrules – beads of once-molten rock that are thought to have formed from dust exposed to temperatures of about 2000 °C. But no one is quite sure how this happened. “It is a very complex problem,” says Brian McBreen of University College Dublin in Ireland, “but somehow nature has done it.”

In the 1960s some researchers suggested that lightning caused by turbulence in the solar nebula could have melted grains of dust, leading to the formation of chondrules. But no one could explain how the lightning could flash across the entire solar system, or even suggest a source of energy for the lightning.

In 1999 McBreen argued that extremely high-energy gamma-ray bursts – believed to be given off when massive stars die – could have provided the energy to turn grains of dust into chondrules (*New Scientist*, 11 September 1999, p 17). The bursts would have had to be within 300 light years of the solar system. But chondrules often contain other chondrules, which means they must have melted numerous times. It is extremely unlikely that enough gamma-ray bursts occurred close enough to do this.

Now McBreen’s team is suggesting that distant gamma-ray bursts could have created lightning in the nebula of gas and dust that made up the early solar system. While gamma rays from 30,000 light years away would not have had enough energy to melt

dust, they could have ionised the hydrogen gas, scattering electrons and leaving positive ions behind. The separation of charges would cause lightning to streak across the solar nebula with enough energy to melt the dust (*Astronomy & Astrophysics*, vol 429, p L41).

Other physicists are sceptical about McBreen’s idea. Steven Desch of Arizona State University in Tempe points out that while lightning would have heated the dust only briefly, the structure of chondrules shows they were warm for hours before solidifying.

Desch had previously proposed a different explanation. As the solar system was forming, it is thought to have had spiral arms in which the density and pressure of gas was much greater than in the central protoplanetary disc. So dust moving into the arms would have been subjected to a shock rather like that experienced by spacecraft re-entering the Earth’s atmosphere. The friction from

“Distant gamma-ray bursts could have created lightning in the nebula of gas and dust that made up the early solar system”

this encounter could melt the dust, and several such events would explain how chondrules formed inside each other.

McBreen agrees that Desch’s explanation is possible. And while he accepts his idea of gamma-ray induced lightning has only a slim chance of occurring, that does not mean it never happened. “It’s a strange and violent universe,” he says. “If you asked someone to predict lightning in the Earth’s atmosphere without having seen it, I doubt they’d say it would happen, yet we know it does.” **Katharine Davis** ●

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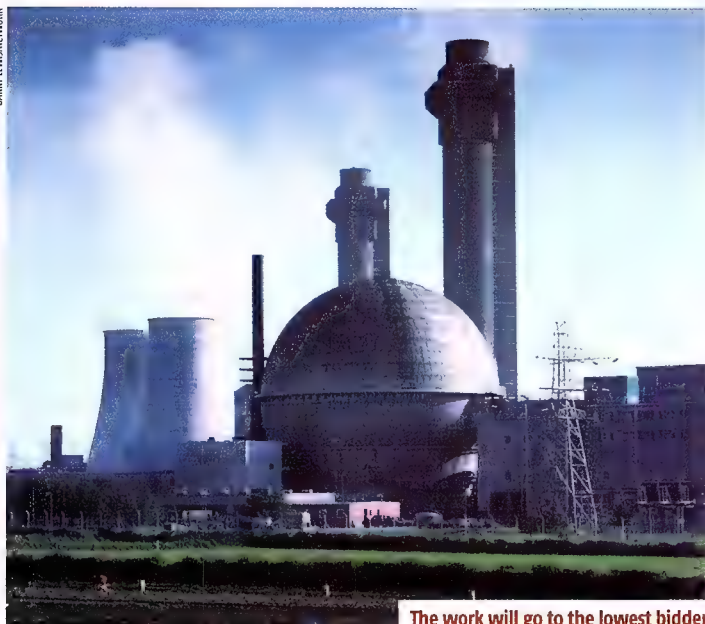
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Nuclear clean-up risks public safety

ROB EDWARDS

PLANS to privatise the £48 billion clean-up of the UK's nuclear sites could put public safety at risk.

The warning comes in documents compiled by the government's nuclear safety advisors released to *New Scientist* under the new Freedom of Information Act. They reveal "serious concerns" about the plans, which will allow private companies to tidy up the radioactive mess left by 60 years of nuclear power. Advisers fear that financial pressures will encourage the companies to cut corners and will increase the risk of accidents.

Work is about to begin on dismantling and cleaning up reactors, waste stores and contaminated land at 20 sites across the UK. The government wants the management of at least half the sites to be put out to competitive tender before the end of 2008. The aim is to drive down costs by allowing private companies to bid

against the state organisations that currently run the sites.

But two expert bodies that advise government ministers – the Nuclear Safety Advisory Committee (NuSAC) and the Health and Safety Commission (HSC) – are worried that competition will harm safety. "Pressure to prepare for competitive bidding in the very short term could compromise safe operation," one memo warns. It argues that managers and workers anxious about their jobs would pay less attention to safety. There is also a danger that in a complicated system of parent companies and contractors profit could come before safety.

The memo was sent by NuSAC in July 2004 to the chair of the HSC, Bill Callaghan, with a

"Pressure to prepare for competitive bidding in the short term could compromise safe operation"

request to make ministers aware of the concerns. It was not until November that Callaghan wrote privately to Patricia Hewitt, the trade and industry secretary. The target of putting the management of 10 nuclear sites out to tender within three years "would be extremely challenging, if not impossible, if sites are to ensure priority is given to continuing effective management and control of safety," Callaghan wrote. It was "regrettable", he said, that regulators had not been consulted on whether the target was "practically and legally achievable".

Hewitt's reply in December stuck to the government's plan to create a "dynamic and open market" for nuclear decommissioning, though she hinted that the timetable could be renegotiated if it really threatened safety. "The experience of the US market suggests that ambitious competition schedules do not lead to a reduction in safety," she insisted.

Ian Jackson, an ex-nuclear inspector for the government's Environment Agency echoes NuSAC's safety fears. He points out that sites with different owners and managers will create "genuine risks" for safety regulators. He adds that the US experience has not been without problems. Its clean-up programme was strongly criticised by a review set up by President Bush in 2002 for "failing to deliver", and has since been revamped.

NuSAC also expressed concern about growing pressures on the government's Nuclear Installations Inspectorate. The minutes of a NuSAC meeting in July reveal that an unpublished 18-month work to rule by inspectors has led to a 15 per cent reduction in site inspections. After a failed recruitment campaign last year, the inspectorate is now 14 short of its full complement of 179 inspectors. "Prolonged reduction of inspection will undermine our ability to effectively monitor the safety performance of the nuclear industry," says Laurence Williams, who recently quit as chief inspector. ●

Sperm damage claims over phone radiation

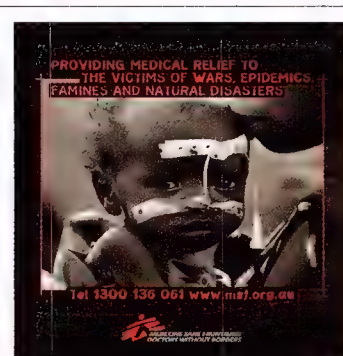
COULD mobile phones damage the health of children before they have even been conceived?

Yes, says John Aitken of the University of Newcastle in New South Wales. He claims to have preliminary evidence that radio waves of the frequency used by mobile phones can damage sperm DNA in mice. "It won't affect you, but it could affect your children," he says.

Aitken's team exposed 22 mice to 900-megahertz radiation at an estimated rate of 90 milliwatts per kilogram of bodyweight – less than most people receive from mobile phones – for 12 hours a day for one week. A sensitive technique called quantitative PCR found more DNA damage than in sperm from controls, the team will report in the *International Journal of Andrology*.

But even if he's right, mobiles would probably have far less impact on sperm than smoking or occupational exposure to toxic substances. And Camelia Gabriel of Microwave Consultants in London, who is researching the health effects of microwaves, is not convinced. "The estimation of the animals' exposure to radiation is not rigorous enough to put much weight behind the claims," she says. There have been numerous claims that radio waves can have effects on living tissue other than heating, but so far none has been confirmed by independent tests.

Rachel Nowak, Melbourne ●

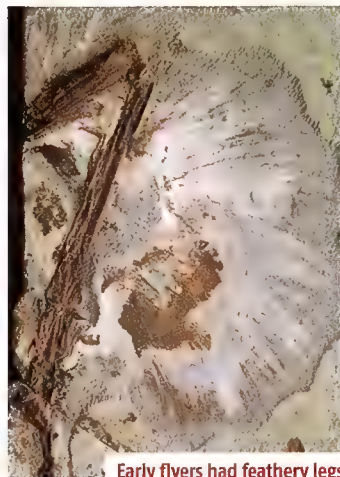


Can 'feather foot' knock oldest bird off its perch?

JEFF HECHT

A SMALL Chinese dinosaur with large feathers on its leg has stunned the world of palaeontology. The fossilised leg bones of *Pedopenna daohugouensis* reveal it to be as bird-like as archaeopteryx, till now the oldest known bird. But its discoverers think that *Pedopenna* may be even older.

Until two years ago, when flight feathers were discovered on the hind legs of the small dinosaur *Microraptor gui*, no one suspected that back legs also played a role in flight (*New Scientist*, 25 January



Early flyers had feathery legs

2003, p 14). Long leg feathers also turned up on some archaeopteryx specimens on closer examination, but whether they were important for the first flyers or developed later is still a mystery.

Xu Xing of the Institute of Vertebrate Palaeontology and Palaeoanthropology in Beijing, who discovered both fossils, says the new find shows *Microraptor*'s leg feathers were not an evolutionary fluke. And although the *Pedopenna* specimen is only 12 centimetres long, that is enough to show its closest kin were birds and dromeosaurs, the dinosaur family which includes *Microraptor* (*Naturwissenschaften*, DOI: 10.007/s00114-004-0604-y).

Pedopenna or "feather foot" would have been less than a metre long and was found in the Daohugou fossil beds of Inner

Mongolia. This makes it older than the slightly smaller *Microraptor*, but how much is not yet clear. From examining other fossilised creatures of known age that appear with *Pedopenna*, Xu concludes it lived in the late Jurassic period, which ended 145 million years ago. That could make it older than archaeopteryx, which dates from around 150 million years ago in what is now Germany.

If the fossil beds turn out to be this old, the exquisite preservation of the Daohugou fossils means it could be an extremely significant location for studying the origins of birds, says Xu.

However, their age is still in doubt. Huai Yu He of the Institute of Geology and Geophysics in Beijing last year suggested they may be less than 140 million years old (*Geophysical Research Letters*, vol 31, L20609). ●



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Deaf guinea pigs get hearing back

GENE therapy has partially restored hearing in deafened guinea pigs, raising hopes that the approach might work in people.

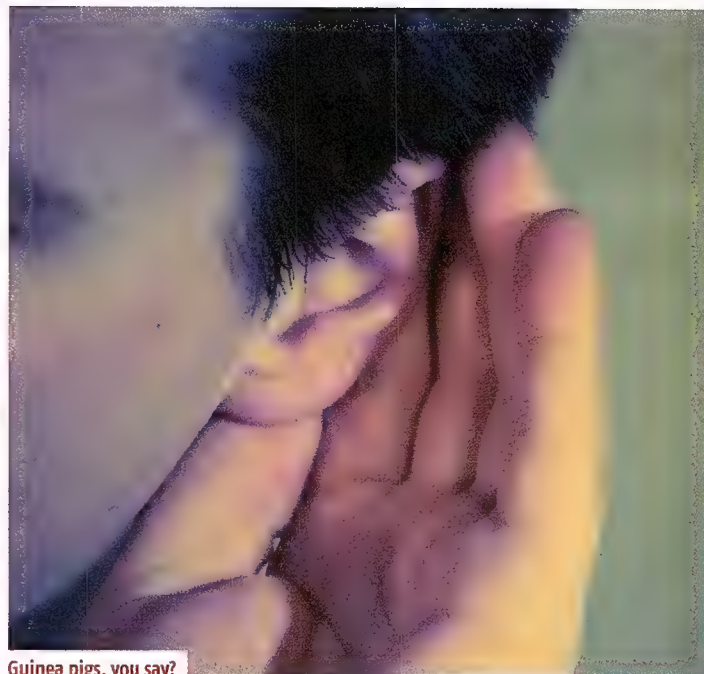
"It's the first time anyone has biologically repaired the hearing of animals," says Yehoash Raphael of the University of Michigan in Ann Arbor, head of the US-Japanese team that is developing the therapy.

Millions of people each year go deaf when the sound-detecting hair cells in the inner ear are destroyed by certain antibiotics, old age or loud noise. These cells do not normally regrow in mammals, but two years ago Raphael's team managed to grow new hair cells in deaf guinea pigs using gene therapy (*New Scientist*, 7 June 2003, p 15).

However, the presence of new hair cells alone was not enough to prove that the guinea pigs could hear again. So in their latest experiments, the team measured the animals' auditory brainstem response. This test, sometimes used to assess hearing in people, involves recording brain waves using electrodes to find out if the brain is responding to sounds.

The results exceeded the team's expectations. "The recovery of hair cells brought the treated ears to between 50 and 80 per cent of the hearing thresholds they'd had originally," says Raphael, whose results appear in *Nature Medicine* (DOI: 10.1038/nm1193).

But human trials are still some way off. The gene that stimulates hair cell growth is added to cells using modified cold viruses, and there is a risk people could react badly. Injecting the virus is also more difficult in humans. Andy Coghlan ●



PAUL HARRYTORRES

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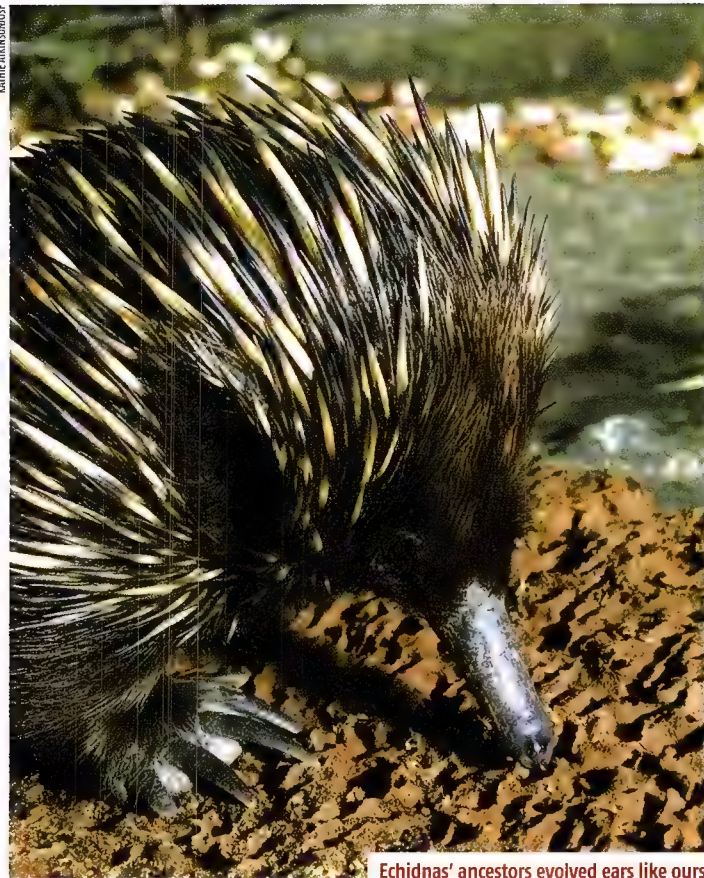
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Echidnas' ancestors evolved ears like ours

JEFF HECHT

EVOLUTION can repeat itself – even in producing complex structures like the mammalian middle ear. A fossil jawbone from an early Australian mammal proves that the hearing of at least two different groups of mammals developed independently in almost exactly the same way.

The discovery raises both philosophical and practical questions. It challenges the claim made by the late biologist Stephen Jay Gould that replaying the evolutionary “tape of life” would produce different results. The finding that the same trait evolved

more than once implies the contrary: that natural selection tends to converge on a limited range of options. Simon Conway Morris of Cambridge University, who famously clashed with Gould over the subject, described the findings as “music to my ears”.

What is more, it questions a key premise made in drawing up evolutionary family trees – that all animals which share a trait have a common ancestor. If this assumption should prove to be untrue, then reconstructing evolutionary relationships becomes much harder.

The middle ear of mammals is an ideal test case for Gould’s ideas.

Its three tiny bones, the malleus, incus and stapes or hammer, anvil and stirrup, are connected to form an exceptionally sensitive acoustic receiver. This complex structure is present in all living mammal groups – placentals, marsupials, and the egg-laying monotremes, which include the echidna and duck-billed platypus.

Its origins can be traced to three bones attached to the lower jaw of mammal ancestors that shared the planet with dinosaurs. These bones transferred vibrations from the lower jaw to the eardrum. As the jaw evolved, the three bones shrank and eventually detached, migrating with the eardrum to the middle ear. The process was so complex that mammal experts assumed

“The advantages of the middle ear are so great it was inevitable it should evolve twice in two groups with similar constraints”

that it must have occurred only once, before monotremes split off from the other mammals more than 150 million years ago.

Now Thomas Rich at the Museum Victoria in Melbourne, Australia and his colleagues have found evidence that a 115-million-year-old monotreme called *Teinolophos* had not yet developed modern hearing. The shape of its teeth showed it was a monotreme, but its jaw had a trough to accommodate the three bones, which were still attached.

So both monotremes and other mammals must have developed middle ear bones independently after the evolutionary split (*Science*, vol 307, p 910). A few other cases of independent evolution are known, but all are simpler innovations such as the molar teeth in mammals.

Fossil mammal expert Zhe-Xi Luo of the Carnegie Museum of Natural History in Pittsburgh thinks the advantages of the mammalian middle ear are so great it was “inevitable” that it should evolve independently in two groups with similar design constraints. ●

Young blood restores body's healing powers

THE blood of young mice has the power to heal – and surprisingly it seems to have little to do with the stem cells it contains. If the factors responsible can be identified, it might be possible to develop drugs that help older people recover from injuries more quickly.

That is the conclusion of Thomas Rando of Stanford University in California. He and his colleagues stitched together pairs of almost identical mice of different ages to create artificial conjoined twins. The mice gradually grew connecting blood vessels, so they came to share the same circulatory system.

Old mice twinned with young partners were able to regenerate muscle cells faster and formed less scar tissue than old mice twinned with old partners, the team found.

“It’s a dramatic improvement,” says Rando, although the healing was still not as fast as in young mice. Liver regeneration was similarly improved, suggesting that the effect may apply to all kinds of tissues (*Nature*, vol 433, p 760).

One explanation for the rapid healing could have been that stem cells from the young mice were helping to regenerate tissues in their older partners. But because some of the young mice had been modified to produce a green fluorescent protein in all their cells, the team were able to rule out this possibility.

This suggests that the main reason older bodies repair injuries more slowly is not because stem cells lose their regenerative ability, but because there is a shortage of whatever signal tells them to repair damage. The team is now working to identify that signal. The researchers hope that giving older people the factor or factors involved could at least partly restore their healing powers.

But such a therapy would not be a cure-all for the ailments of old age, Rando cautions. It might help tissue repair itself better, but it would not prevent ageing. Bob Holmes ●

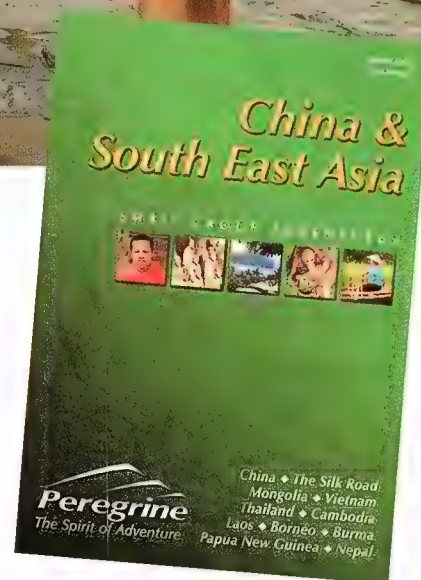


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NS050P02

In brief



Mosquito eaters help villagers beat dengue fever

TINY crustaceans that eat mosquito larvae could make a big difference in the fight against dengue fever.

"We've had almost total success eliminating mosquitoes in 37 communes in Vietnam, and it's been done by the local people," says Brian Kay of the Queensland Institute of Medical Research in Brisbane, who set up a control programme with Vu Sinh Nam of Vietnam's health ministry. There have been no cases of dengue in these communes, and the scheme will be extended to other areas.

The scheme relies mainly on freshwater copepod crustaceans about a millimetre long that eat young mosquito larvae (*The Lancet*, vol 365, p 613). The team teach people to recognise local species of the genus *Mesocyclops* and transfer them to water tanks and wells where there are none. "The kids can pick them out very quickly," Kay says.

The most severe form of dengue fever, dengue haemorrhagic fever, has spread to 60 countries across the tropics. The new approach might help fight it in rural areas but is unlikely to work in cities, where there are usually too many small containers that hold water in which mosquitoes can breed. And it cannot be used in Africa because copepods can transmit the guinea worm parasite.

Language doesn't count in maths

NOAM CHOMSKY'S theory that the evolution of language provided the portal to all higher thought has taken another knock. A study of people with language difficulties suggests that mathematical skill evolved independently.

A team led by Rosemary Varley at the University of Sheffield, UK, studied three people with extensive damage to the brain's left hemisphere, including

language areas. Two could not speak at all, and the third only in fragmentary sentences. All were competent calculators, though, able to solve simple subtraction, division and multiplication problems (*Proceedings of the National Academy of Sciences*, DOI: 10.1073/pnas.0407470102).

The patients could not spot syntax-based changes in meaning, for instance, in reversible sentences such as "the boy chased

the girl" and "the girl chased the boy". But they had no trouble with a mathematical equivalent such as 7 - 2 and 2 - 7.

Most experts believe that understanding syntax is essential for processing mathematical statements. "We've blown that one to pieces, I think," says Varley.

Psychologist Brian Butterworth at University College London points to evidence that infants do maths long before they can speak. "The syntax of numbers is very different from the syntax of language," he says.

Oldest humans

MODERN humans appeared 35,000 years earlier than we thought. According to new dates for two Ethiopian fossils, we have been around for 195,000 years.

Discovered along the Omo river in 1967 by anthropologist Richard Leakey, the remains were originally thought to be 130,000 years old. However, most researchers doubted they were older than 100,000 years. Now modern radiometric and geological techniques show their age was actually underestimated (*Nature*, vol 433, p 733).

Two years ago other remains from Ethiopia were dated to about 160,000 years (*New Scientist*, 14 June 2003, p 4), confirming that we evolved in Africa.

Team member John Fleagle of Stony Brook University in New York says the new dating also stretches the puzzling delay before two key events: our species' arrival in Europe and Asia, and the first paintings and carvings, both around 40,000 years ago.

Herb as good as antidepressant

FOR people with severe depression, taking an extract of St John's wort is at least as effective as the prescription drug paroxetine, according to Meinhard Kieser's team at Dr Willmar Schwabe Pharmaceuticals in Karlsruhe, Germany.

Past studies have suggested the herb is no better than a placebo for severe depression. Kieser's team took a different approach, excluding people who responded to a placebo after a few days. The remaining 251 volunteers took either an extract of St John's wort or paroxetine for six weeks (*British Medical Journal*, DOI: 10.1136/bmj.38356.655266.82).

The herb can have serious side effects and can also interfere with other drugs.

Forests return but gene pool shrinks

A TROPICAL forest ravaged by logging can recover, but the new growth will probably be much less genetically diverse. This makes it more vulnerable to threats such as disease and climate change.

In many tropical countries, "second-growth" forests now cover a greater area than old-growth forests. Uzey Sezen and his colleagues at the University of Connecticut in Storrs wanted to see how genetically diverse these regenerated patches are. They studied 20 hectares of forest in Costa Rica that was cleared for cattle ranching in the 1960s but has been left to recover since 1978.

Sezen's team picked a common canopy palm tree (*Iriarte deltoidea*) and took a DNA fingerprint from each individual in the second-growth forest to work out its parentage. There were 66 candidate parents, all mature trees from the old forest, but the scientists found that just two of them had produced more than half the offspring in the plot (*Science*, vol 307, p 891). "There are 64 other trees over there," says Sezen. "Why did these two trees go crazy?"

The palm flowers all year round so he suspects the unequal reproductive success was an accident of timing: those two trees produced seeds just as the cleared land was beginning to recover. The genetic diversity of other plant species with similar flowering patterns might also be reduced in the same way.



Why vaccination by potato got chopped

ONE of the first human trials of an edible vaccine produced promising results. But the vaccine, a potato genetically engineered to produce a hepatitis B protein, has been abandoned because of fears that "pharm" crops could be mixed up with normal produce.

Details of the potato's trial have only just been published in *Proceedings of the National Academy of Sciences* (DOI: 10.1073/pnas.0409899102). When 42 volunteers ate two or

three doses of the raw potato, concentrations of hepatitis B antibodies in their blood increased up to 60-fold.

The idea of edible vaccines like this was to enable developing countries to produce cheap vaccines that could be stored without refrigerators. But enthusiasm has cooled because of fears that vaccine-laden fruit and veg might be confused with normal produce, with potentially dangerous consequences.

So the team that developed the

vaccine axed the project two years ago. Instead, it is switching to producing vaccines in non-food plants such as *Nicotiana benthamiana*, a relative of tobacco. The idea is to immunise people by giving them pills containing the preserved, ground-up leaves of the plants.

"We don't say 'edible' any more," says team leader Charles Arntzen of Arizona State University, one of the pioneers in the field. "We say, 'heat-stable oral vaccines' now."

Titan's message on the wind

RADIO telescopes on Earth have picked up faint signals emitted by the Huygens probe as it descended through the atmosphere of Saturn's moon Titan on 14 January. This has allowed astronomers to measure the winds on Titan.

Due to a command error, the Cassini orbiter that released Huygens failed to pick up the signals. That meant the wind experiment would have been a total failure, except for the radio telescopes on Earth. Although Huygens was more than a billion kilometres away and its transmitters had roughly the power of a mobile phone, the sensitive telescopes picked up the signals and detected tiny Doppler shifts in their frequency that betrayed the probe's motion as it was blown about by Titan's winds.

Astronomers have calculated wind speeds of 400 kilometres per hour about 150 kilometres above Titan's surface, but only a few metres per second at the surface itself. However, midway through its descent the probe appeared to be unexpectedly buffeted by rapidly fluctuating winds. "[That] is a bit of a surprise," says Michael Bird of the University of Bonn, Germany, head of the Doppler wind speed experiment.



ROGER HESS/REUTERS

No blow from slumping volcano?

VESUVIUS is sinking, making the kind of eruption that buried Pompeii in AD 79 less likely, according to Andrea Borgia from the European Development and Research Agency in Rome, and his colleagues.

The slumbering volcano, which last erupted in 1944, sits on a layer of sediment. "The volcano is sinking into the sediments," says Borgia. Satellite radar measurements of the volcano's height show the central cone is sinking at a rate of 1 to 2 millimetres per year, while an arc-shaped ridge is rising up at the foot of the slopes. Borgia says these features, and

fissures that have appeared in the flanks, are caused by the sides of the volcano spreading out (*Geophysical Research Letters*, vol 32, p 103303).

He argues that gas from the magma beneath will escape through the cracked sides, lessening the risk of an explosive eruption. Instead, rivers of lava may flow down the slopes. "They will be very destructive as well, but maybe people will be able to run away," Borgia says.

But Bill McGuire, a volcanologist with the Benfield Hazard Research Centre in London, is not convinced that the features Borgia's team has seen affect the volcano's danger levels. "I would certainly not want to see any modification of the current assessment of volcanic risk," he says.

Cyber-antiquities

Collectors of science and technology are ignoring the gems that created the modern world. They are missing a golden opportunity, says **Jeremy Norman**

NEXT week, the world's first auction of rare manuscripts and artefacts charting the origin of the internet will take place at Christie's in New York. That it should have taken more than 30 years after the development of the internet for this to happen speaks volumes about the collectors who specialise in the history of science and technology. They tend to be a conservative bunch who are preoccupied with the world of science in the 19th century and earlier. But science has moved on and I believe the world of collecting must change too.

The library for sale is mine. It draws together important documents from the history of computing, networking and telecommunications. It contains rare books that date as far back as the 17th century, including the first edition of the mathematician John Napier's book describing a mechanical way of speeding up the use of logarithms (estimated price \$25,000-\$30,000). This classic is typical of the manuscripts that many collectors look for: it is old, significant and valuable, all of which help make such items relatively straightforward to spot.

But much of my collection dates from the latter half of the 20th century. A good example is a copy of Vint Cerf and Robert Khan's paper describing the protocol used to send information over the internet, which dates from 1974 (estimated price \$2000-\$3000). It is just one of many hundreds of thousands of technical papers published in the 1970s that are still available today. With so much material to pick from, spotting which of these modern papers is significant, and therefore valuable, may be more difficult than collecting the well-known classics of earlier centuries. Collectors who want to specialise in the modern era must understand today's technology and its origins.

The internet, for example, has its origins in three branches of technology: computing, telecommunications and networking, and my library contains items in all these areas. It started with

my purchase in 1998 of a small collection that included rare documents by authors such as Alan Turing, the father of modern computing, and the mathematician John von Neumann, who developed much of the early theory of computing.

This gave me the confidence to build a collection on topics that in my experience had been extremely difficult to collect. I next purchased a collection of rare editions by Charles Babbage, the inventor of the mechanical Analytical Engine, the first programmable computer, and the author of the first computer programs. I went on to buy details of the design and operation of the first commercially available computer in the US, the Universal Automatic Computer or UNIVAC. The documents had been preserved by Ralph Mullendore, an engineer at the US Census Bureau who was in charge of maintaining this famous early machine.

Finally, I bought the papers of John Presper Eckert, an electrical engineer at the University of Pennsylvania who in 1946 co-invented the first large-scale

general-purpose electronic computer, the Electronic Numerical Integrator and Computer, or ENIAC. By selling his computers, Eckert became one of the founders of the electronic computer industry. And since he also developed the UNIVAC, his papers merged perfectly with those of Mullendore.

During this time I was also acquiring as many relevant individual items as I could. Because the importance of the internet was clear, I collected documents relating to the development of telegraph networks, which were the earliest data networks, and on the invention of telephone, radio and television, and on the mathematical theories of communication and data communication. In the end, I assembled about 1000 items on topics ranging from the mathematical theory of communication to the origins of bioinformatics.

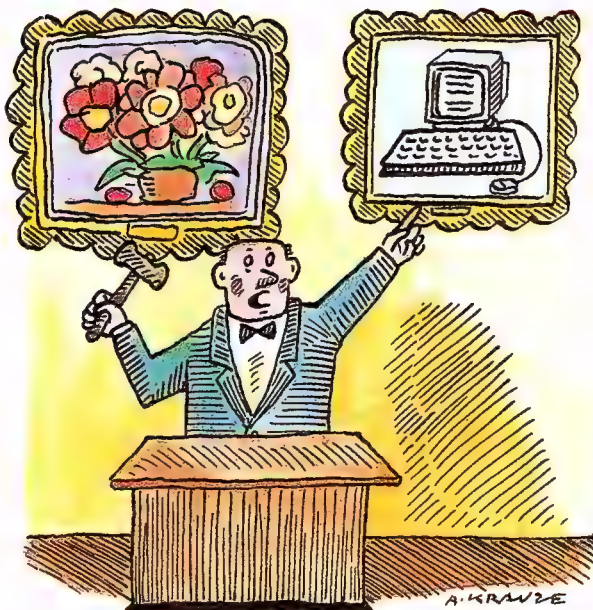
A number of factors worked in my favour. While computing and the internet are widely recognised as a hugely important technologies, few institutional or private libraries collect artefacts and documents recording their origins. That meant less competition for the documents that did come up.

And copies of these documents are rarer than you might think. They were often issued as technical reports and circulated to only a small number of people, who had a habit of discarding them. Today, fewer copies of some of these documents are preserved in libraries than copies of some 15th-century books. This significantly enhances their value.

I found assembling my library hugely rewarding. From the treasures it contained I have been able to write two books about the birth of the internet. But now I am finished. As a dealer in rare books and manuscripts, I want to sell. With the internet still relatively young but 800 million people already connected, it is hard to imagine a time when interest in the origins of cyberspace will be much greater. What better time to realise my investment? ●

Jeremy Norman is a rare book dealer specialising in the history of science. His *Origins of Cyberspace Library* will be auctioned on 23 February. More information at www.christies.com/promos/feb05/1484/overview.asp

"Today, libraries hold more copies of some 15th-century books than certain modern papers"



Cleaning up in the carbon trade

Ian Lowe looks at the antipodean impact of implementing the Kyoto agreement, and at the water politics of Western Australia

AFTER years of negotiation, the Kyoto Protocol finally came into force last Wednesday. That means the European Community and 35 other industrialised countries, including New Zealand, are now legally bound to reduce their combined emissions of six major greenhouse gases during the 2008–2012 period to below their 1990 levels.

The NZ target is to return emissions to the 1990 level, because most of its electricity already comes from non-carbon sources. The treaty provides for "emissions trading", allowing the parties to buy and sell emissions credits amongst themselves. The argument is that this market-based approach will make emission reduction more cost-effective.

And NZ's private companies will be able to make profitable investments in emission-reducing projects in developing countries under the Clean Development Mechanism and the provisions for Joint Implementation. These projects can contribute to the national reduction target.

Unlike most other multilateral environmental agreements, the Kyoto protocol actually has teeth. Parties to the treaty, such as NZ, will be audited in 2013 to verify they have met their commitments for the period 2008–2012. If this expert review of NZ's emissions should find the country has not met its target, it would be expected to make up the shortfall by purchasing emission rights on the world market.

If it failed to do so, then it would have to make up the difference in the following commitment period, with a penalty of 30 per cent extra reduction. The country would have three months to develop a compliance action plan to meet its revised target. Until that happened it would not be allowed to sell emission rights. And

it would run the risk of being publicly shamed by the treaty's "enforcement branch".

If all that looks daunting, remember that Australia is at this stage locked out of the emissions trading regime and any investment opportunities, as it hasn't ratified the treaty, along with the US, Monaco and Liechtenstein. It is also fair to note that few of today's responsible ministers will still be in office in 2013, although their planning will determine whether compliance is achieved after 2008.

I think we can expect a whole lot of blaming of previous governments in countries that fail to meet their targets—with more justification than usual for that tired old excuse.

WE DON'T often see technology become a major election issue. But it's happening in Western Australia, which goes to the polls next Saturday.

Water supply is a significant issue in the Perth area, where most voters live. Climate change has seen a dramatic reduction in run-off to Perth's water supply dams. The average figure since 1997 is about one-third of that from 1900 to 1975. So Perth has water restrictions, and a brisk debate over using large amounts of water on suburban gardens.

The Gallop government decided to build a A\$350 million desalination plant to provide water from the Indian Ocean. It will use reverse osmosis, the same process as the plant operating on Kangaroo Island. The government also has set up an expert panel to examine other proposals, including bringing water nearly 4000 kilometres from the Kimberley region.

The idea to build a pipeline or a covered canal to bring this water south to Perth has

surfaced several times since the 1980s. Leader of the Opposition Colin Barnett has taken a "crash through or crash" approach. In a televised debate with the Premier, he has already promised to go ahead and build the covered canal if elected.

Barnett's promise ignited a vigorous public debate. Business interests attacked the idea, the WA Chamber of Commerce calling it reckless. *The Australian* newspaper labelled it "populist politics" and wondered in an editorial, "if engineering is the answer, perhaps Mr Barnett could explain why a canal is superior to a comprehensive recycling system". But his grand gesture could well appeal to voters.

I have to declare an interest. I am a member of the expert panel that will examine the proposals if the present government is re-elected. I think it is only sensible to study such issues as the economics, the environmental impacts and the implications for local communities in the Kimberley, as well as comparing the proposal with other approaches.

I SOMETIMES wonder about the technology used in supermarkets. Puzzled by what seemed an unusually steep total at the check-out last week, I went through the receipt item by item. I had been charged \$54.90 for a cucumber.

Instead of weighing vegetables at the check-out, the shop had individually wrapped the cucumbers in plastic and attached bar codes. Presumably there was a glitch in the code that translated my purchase into the most expensive salad item ever sold. You begin to worry when the process of swiping bar codes through a scanner is so mesmerising, that the operator doesn't even notice such a gross error.

SOME people will do anything...Neither I nor my subeditor noticed that Albert Einstein's anti-matter twin, "Alfred", had crept into the Antipodes column of 5 February to usurp his brother's place in the Universe. Thank you to reader John Hutcheson for exposing this fraud.

ENIGMA 1328

Prime pyramid

Mike Thorley

A triangular-based pyramid is constructed of three tiers of blocks, lettered sequentially A to C, D to I and J to R as shown. Carolyn and Chris were to replace the letters with digits, so that A, B and C were all different, A+B+C was even, and AC was to be a prime.

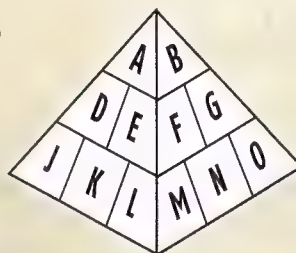
All sequential digit pairs AB, BC, ..., QR

were to be primes, except DE. Similarly, all sequential digit triads ABC, BCD, ..., PQR were to be primes, except CDE. On the 'A' pyramid face AD, DJ, AE, EL and AEL were all to be primes, as were ADE, DJK and EKL; the same was to be true for the corresponding digit pairs and triads on the B and C faces.

Chris and Carolyn each found a solution, differing only in one of the eighteen block faces, Chris's having the lower digit.

Send in (i) the letter of the position with

the different digits in the two solutions, (ii) Chris's and Carolyn's digits for this position.



£15 will be awarded to the sender of the first correct answer opened on Tuesday 22 March. The Editor's decision is final. Please send entries to Enigma 1328, New Scientist, Lacon House, 84 Theobald's Road, London WC1X 8NS, or to enigma@newscientist.com (please include your postal address). The winner of Enigma 1328 is Frank Gidlow of Walsall, West Midlands, UK

Answer to 1322 Geometric runs
The scores were 27 and 125.



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\$11,000 University of Sydney Sleek Geeks Science Eureka Schools Prize For a short video by secondary students communicating a scientific concept in an accessible and entertaining way. *Sponsored by the Faculty of Science at the University of Sydney with support from Abbey's Bookshop and Microsoft*

Entries close 13 May 2005

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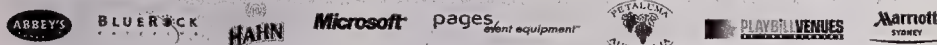
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Pentium's reign in jeopardy

A radically different chip with massive processing power is making waves in the computer industry



The Cell's master processor is like Apple's G5

CELESTE BIEVER

THE supremacy of the Pentium is to be challenged by a revolutionary chip with massive processing power. But experts are divided over whether the Cell, which was launched last week, will be enough to end Intel's 20-year domination of the PC market. Some see the new chip as the future of personal computing; others say that the huge quantity of software designed to run on Intel's chips has made the company's position unassailable.

The Cell is a joint effort by IBM, Sony and Toshiba. Unlike the Pentium, it is a parallel-processing chip that contains no fewer than nine high-power microprocessors that communicate with each other using supercomputer-like links.

Once the design is perfected, says IBM, a single Cell chip will be

capable of processing data at 256 billion floating point operations per second (256 gigaflops), which makes it roughly an order of magnitude faster than today's Pentium 4 chips. The Cell's clock speed of 4 gigahertz is only 0.2 gigahertz faster than the Pentium, but its parallel architecture ensures it can process many more instructions in a given time.

The first application for the Cell is likely to be in bringing fluid, cinema-quality graphics to games on Sony's next-generation PlayStation 3 console, which is expected to contain four of the chips. "To see a processor this powerful go into a toy is just remarkable," says Tom Halfhill, an analyst for the *Microprocessor Report* newsletter in San Jose, California.

With its nine processors, the chip has some commentators predicting the demise of the Intel-

based PC. Intel itself recently abandoned the idea of increasing computing power by continually boosting the clock speed of its single-processor chips. This was because of the ever-increasing amounts of heat produced as more transistors are packed into them. So Intel too will move to chips that divide up tasks and share their processing between at least two separate processor "cores". But the Cell appears to have leapfrogged Intel's plan in a big way.

"Unlike Intel's Pentium, the Cell was designed from scratch to deliver cinema-quality graphics and to decompress multiple channels of streamed video," says Richard Doherty, an analyst with the Envisioneering Group in Seaford, New York. "This is what consumers are increasingly demanding." He thinks the Cell could easily form the heart of future PCs.

But Jon Peddie, a technology analyst based in Tiburon, California, disagrees: "The Cell is not a Pentium-killer. There is already 20 years' worth of software and one billion people reliant on the old architecture. They are not going to just give this up." Intel, of course, agrees: "Writing software for a radically new architecture is hard and takes a long time," says spokesman George Alfs.

IN THIS SECTION

- Nanotubes clean up water, page 24
- GPS-guided trains, page 25
- Internet phones to take off, page 26

"The power of the chip's nine processors has some people predicting the demise of the Intel-based PC"

They have a point. The only software the Cell's lab prototype has run so far is a modified version of the Linux operating system. And the chip is unlikely to speed up everyday PC tasks like web browsing, emailing, word processing or listening to music.

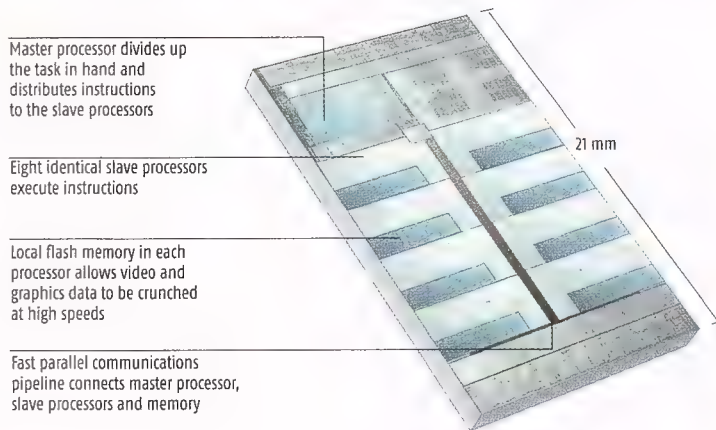
However, all agree that the Cell should vastly improve computer graphics, video games and streaming multiple video channels – watching one while recording a handful of others, say – in future high-definition TV sets, games consoles or specialist home entertainment computers. "It will be a really great games console processor and general multimedia accelerator," Peddie says.

Today's single-processor chips struggle to produce cinema-quality graphics or run applications simultaneously. Bottlenecks quickly build up because they are designed to retrieve just one piece of data at a time from memory. The Cell can make 128 memory requests in one go, says Peter Hofstee of IBM's lab in Austin, Texas, who was one of the Cell's designers.

Its architecture is the key. ►

NINE PROCESSORS IN ONE

The heart of the PlayStation 3 could also end up in supercomputers and high-definition TV sets



The Cell has a 64-bit "master" processor – similar to the G5 used in today's top-end Apple Macintosh – which orchestrates the activities of eight 32-bit "slave" processors. Each slave has its own 256-kilobyte local memory and is connected directly to the chip's main memory via a high-bandwidth pipe. "The Cell certainly has a useful architecture for problems like gaming graphics that have humongous arrays of data," Peddie says.

Because the chip's master processor is so like a G5, Apple's army of diehard fans have been speculating on the internet that it might be straightforward for Apple to tweak its newest OSX operating system to run on the Cell. "For Apple to let this opportunity slip by would be uncharacteristic," Halfhill says.

After PlayStation 3, the Cell's next stop could well be supercomputing. Bill Kramer, a researcher at the Lawrence Berkeley National Laboratory in California, already likens it to a "supercomputer on a chip". While

"It's surprising that something as frivolous as games should be driving computer chip innovation."

a single Cell chip comes nowhere near performing the 70,000 gigaflops of the world's fastest supercomputer, Kramer hopes to strap hundreds of Cells together to form a small, low-power supercomputer. However, the chip's architecture means that it may never rival a conventional supercomputer. Jack Dongarra of the University of Tennessee in Knoxville says that the chip can only do calculations accurate to 32 bits, or eight decimal places. Scientific computing tends to require at least 64 bits.

The most interesting thing about the Cell, Halfhill says, is that it is an example of a new trend in computing. "It's surprising that something as frivolous as games should be driving computer chip innovation," he says. ●

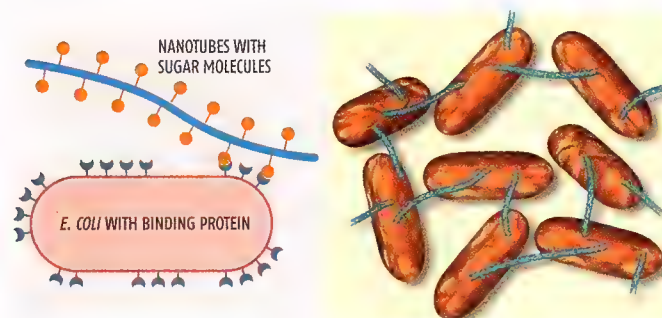
Nanotubes get to grips with the 'burger bug'

WATER PURIFIER

Bacteria can be removed from water by forcing them to stick together in clumps that can be filtered out

Modified nanotubes coated with sugar molecules bind to sugar receptors on the bacteria

The nanotubes bind to large numbers of bacteria, forming clumps



STRIPPING potentially fatal bacteria from drinking water supplies could be one of the first real-world jobs for carbon nanotubes.

In experiments that could easily be scaled up to a practical level, researchers have developed nanotubes that can trap bacteria by making them stick together in clumps. These can then be sieved out of the water and destroyed.

Ya-Ping Sun, whose team developed the nanotubes at Clemson

University in South Carolina, says that the first application could be in filters at water purification plants. "How soon depends on funding and the interest of industrial collaborators," he says. The results of his research appear in the latest edition of the journal *Chemical Communications* (2005, p 874).

Sun's nanotubes trap *Escherichia coli* O157:H7, the notorious "burger bug" that can be lethal to people who eat contaminated meat. He coated

the nanotubes with molecules of the sugar galactose, which stick to receptor proteins on the surface of the bacteria. Each nanotube sports hundreds of sugar molecules and so can capture large numbers of bacteria at a time (see Graphic).

Sun's team has also developed a nanotube that traps another common food-poisoning bug, *Campylobacter jejuni*, which is often found in chicken. This time he coated the tubes with mannose, a sugar which binds to receptors on the surface of *C. jejuni*. "We are now working toward the idea of a single nanotube with multiple ligands [sugars] for different bugs. It is feasible," he says.

In theory nanotubes could be used to filter bacteria out of a patient's blood, though they would need to be tested first to rule out any toxic effects. "In the future, interactive biomaterials like these carbon nanotubes offer potential to selectively capture, lock up and destroy pathogenic bacteria," says Peter Arnold of UK-based medical technology company Smith & Nephew, which is developing biomaterials that speed tissue repair.

Kevin Matthews of Oxonica, an Oxford-based company developing nanomaterials for clinical diagnosis, said that Sun's work is a great example of the convergence of traditional inorganic chemistry with biochemistry, "offering greater possibilities than either technology independently". Andy Coghlan ●

CUTTING EDGE

MAKING MOBILES PAY

You could soon be paying for the groceries or a train trip with a simple swipe of your cellphone. Nokia has signed a deal with credit card firm Visa to include radio-frequency ID chips in mobile phones, so that the phone can be used to pay for goods or services simply by passing it over a reader.

Users must tell Visa in advance what they want to pay for in this way. At the point of sale, the phone sends a burst of encrypted data to authorise payments. The user is then billed for the service.

RFID-chipped Nokia 3220 phones will go on sale later this year. The technology

will first be used on buses in Hanau, near Frankfurt in Germany. Nokia says the phones could soon be used to pay for journeys on London's underground. The worry is that it will give thieves yet another reason to steal cellphones.

BOOST TO PHOTONIC CIRCUITS

Light from silicon-based lasers has always been too erratic to be of any practical use. But two experiments reported last week raise hopes that the lasers will eventually be steady enough to drive ultra-fast optical microchips. Both experiments use light from an external laser to "pump" the silicon atoms into a

state in which they can emit light.

Engineers at Intel in California got a silicon laser to produce a steady beam by guiding the pumping laser through an S-shaped path in a silicon wafer (*Nature*, vol 433, p 725). The longer path means the pumping light can be amplified enough to sustain a continuous output from the silicon.

Another challenge was to control silicon laser beams electrically. Engineers at the University of California in Los Angeles succeeded in switching a silicon laser on and off by varying a voltage applied across the path of the pumping beam (*Optics Express*, vol 13, p 796).

Satellite train trial gives the all-clear

MICK HAMER

REPLACING railway signalling equipment with satellite navigation systems could slash the cost of maintaining the network and provide a financial lifeline for lightly used rural railways by cutting their costs.

A nine-month trial using a train on the UK rail network, reported at a conference in London last week, showed that the satnav technology could successfully replace trackside signals. It reliably displayed

carried a GPS receiver capable of determining its position to within 4 metres. Using a link to the Iridium satellite communications network, or a mobile phone network if the satellite link failed, the system then broadcast the train's position to signal boxes.

Software feeds this position data into the railway's existing signalling system, which keeps track of all the trains over a broad area of the network. This works out whether to display a danger signal or the all-clear on the panel in the train cab that takes the

place of the trackside signals.

While GPS navigation is used extensively in aircraft and ships, railways were expected to pose more problems. Deep cuttings could block the train's view of the GPS satellite's signal, and electrified sections could interfere with the signal itself or with the cellphone link. The trial proved these fears groundless, and the only blind spots were tunnels. "We knew where the train was to within 4 metres of accuracy," Close says. "We were able to follow it right up to the buffers of [London's] Paddington station, even under the glass canopy on the train shed."

But Peter Ladkin, a safety analyst at the University of Bielefeld in Germany, warns that the system may be unreliable. "It is easy to jam GPS, inadvertently or deliberately." ●

"Fears of interference or blocked signals proved groundless. The only blind spots were tunnels"

signalling information inside the driver's cab, while equipment in the signal control room showed the position of the train.

Maintaining conventional signalling systems can eat up as about 10 per cent of the cost of running a railway. The new system has been geared to help operators of lightly used railways, says Gareth Close of satellite consultancy SciSys, based in Chippenham, Wiltshire, in the UK.

Railway signalling systems divide the track up into short sections, each guarded by a signal that remains at red while the section ahead is occupied. These trackside signals are expensive to maintain and vulnerable to vandalism. In some countries it is not uncommon for people to steal lengths of cable and sell them for the copper they contain.

The trial, which was backed by the British National Space Centre, was the first on a publicly used railway. It followed trials of a similar system on a test track in Belgium last year. The test train



Tune in to a different kind of signal

INVENTION

SUNKEN SIGNAL FOOLS COPYCATS

No matter how clever the digital encryption used by Hollywood to stop people copying movies from TV or DVDs, a bootlegger can still copy movies by plugging the analogue signal into a PC's video "capture" card and recording it on the hard drive. The card will convert the signal from analogue to digital without the copy protection, and the film can then easily be copied.

UK video technology firm Dwight Cavendish suggests in world patent application 2004/110060 that TV receiver and DVD player circuits intermittently increase the strength of the signal's "sync" pulses – used to keep pictures steady on screen. This varies the brightness of the recording, making it unwatchable.

IRREGULAR CHATTER

Terrorists know their emails can be monitored by software that looks for telltale words like "bomb". So they use innocent-sounding code words instead. But Hewlett-Packard thinks it can detect them anyway (US 2004/0236566).

Its idea is to feed intercepted text into two different programs. The first categorises words as nouns, verbs and adjectives by applying standard rules on their normal use, while the second program uses the context to do the same job. Codes tend to involve non-standard uses of a word, so the two programs will classify it differently. If such irregularities show up often in a series of messages from the same address, HP's system alerts the spooks.

WILL THEY OR WON'T THEY?

Critics of the US's increasingly liberal patent office will be keen to see if it grants application US 2005/0005962. Lucent Technologies of New Jersey claims to have invented a portable solar power-generating sunshade. It has a set of solar cells fixed to a panel, so when you put it in a sunny window it shades you and generates power too. If the patent is granted, anyone using a portable "solar energy collector... within a vehicle...or building" may find themselves hearing from Lucent's lawyers. Barry Fox

Net calls take wing with Wi-Fi phones

Cheap internet calls are a draw, but who wants to talk to a computer? A new breed of phone is the answer

DUNCAN GRAHAM-ROWE

THE idea of using the internet to make free phone calls is getting more popular by the minute. But while "voice over internet protocol" (VoIP) phones can save money, having to use a computer for all your phone calls is hardly convenient. That's about to change with the launch this year of cellphones with built-in Wi-Fi capability that link to low-cost internet connections, and a new breed of landline phone that plugs straight into a broadband internet connection. Together these are expected to be the killer development that brings VoIP into the consumer mainstream.

VoIP is a way of conveying phone calls by breaking down voice signals into digital packets and sending them over the internet. Like emails or any other internet data, they are routed

round the net to the internet protocol (IP) address of the recipient. Unlike traditional calls, which tie up a dedicated line for at least part of their journey, this way of working allows several calls to share a single line.

Software is already available free of charge on the internet that allows users to make VoIP calls to each other without payment, as well as paid-for calls to standard phones. In just over a year, 25 million people have downloaded the software from the Luxembourg-based company Skype, for example. Free use is the attraction: only 800,000 of them are making paid-for calls.

As impressive as these sign-up

"A cellphone with the right software, operating in a Wi-Fi network, can function as a domestic and a mobile phone"

TROUBLE ON THE LINE

Viruses, denial of service attacks, phishing scams – all problems that already beset the internet – could threaten our phone calls too if VoIP becomes the norm.

In an effort to pre-empt this, more than 20 communications and security organisations joined forces last week to form the VoIP telephony security alliance (VoIPSA). Its aim is to create a forum for experts to discuss the threats and to fund research on countermeasures.

With members including the internet routing/networking company 3Com, electronics giant Siemens and the global antivirus firm Symantec, the hope

is that the penetrate-and-patch arms race that has plagued the online computing arena will not be repeated in the online phone market.

"VoIP has finally arrived, and vulnerabilities in devices and services which enable this technology need to be discovered and mitigated," said Ron Gula of Tenable Network Security in Columbia, Maryland.

One major worry is that VoIP lines will become subject to the equivalent of spam. Already dubbed "spit", short for spam on internet telephony, the fear is that spammers could begin sending junk voice mails to VoIP subscribers.

numbers might sound, they don't necessarily indicate how often people are using the service, says Keith Nissen, a senior analyst with In-Stat in Scottsdale, Arizona. Even people with the Skype software still make plenty of use of their old landline and mobile phones, he says, partly because they still have to use a computer equipped with a microphone and headphones to make their calls.

This has left VoIP as a niche market, Nissen says. Subscribers tend to be people who save the most because they make a lot of long-distance or international calls. According to In-Stat, only 5 million people worldwide are paying to make VoIP calls to regular phones. For VoIP to really take off, it will need to be as convenient as traditional telephony, and this is where Wi-Fi comes in. A cellphone capable of running VoIP software and operating through a home Wi-Fi network when in range of it suddenly becomes a domestic phone and a mobile phone all rolled into one. At home, the handset will operate as a VoIP domestic line. Elsewhere, the handset switches to the cellular network, operating as a standard mobile.

For large businesses, VoIP has slightly different advantages. Equipping an office with VoIP phones means that calls can run over the same links as computer data, doing away with the need to lease expensive phone lines from telecom firms. Businesses are adding Wi-Fi access to their VoIP infrastructure. Nearly a quarter of medium-to-large businesses in the US give their employees wireless access to VoIP telephony from Wi-Fi-capable desk phones, putting an end to the maze of computer and data cabling found in today's offices. And cellphone companies are now doing deals with the likes of Skype to offer Wi-Fi-capable phones geared for VoIP access.

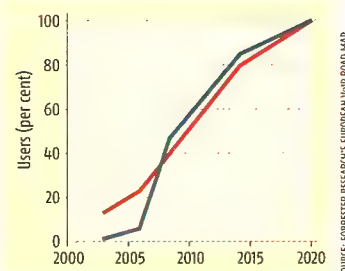
One of the reasons this is happening now is that the quality of VoIP calls on corporate networks has shot up. Until

recently there was no way to prioritise VoIP data packets to ensure that they arrived at their destination address at the right time and in the right order to be reassembled into speech. As a result, VoIP calls have often had that curious RealAudio-in-the-early-days gurgling sound to them, as if callers were talking under water. But hardware now being installed to route data round office networks can overcome this, by prioritising VoIP packets over, say, email

INTERNET PHONES IN EUROPE

Europe's use of VoIP is set to grow hand in hand with broadband

● VoIP ● Residential broadband



and file-server requests.

Another reason is that the telecommunications industry, afraid to be caught napping, is keen to adopt the new technology. Not only have phone companies had to watch revenues dwindle from calls made on landlines, but they also had to fork out billions to governments in 3G mobile phone bandwidth licensing fees. Now with VoIP threatening both landline and mobile revenues, mobile operators will be scrambling to offer dual use mobile network and Wi-Fi/VoIP phones to ensure they get at least a slice of the VoIP action.

For calls travelling further afield, however, guaranteeing quality of service is going to get tougher as the number of VoIP user increases (see Graph) and bottlenecks on the net push call quality down again. In the long run, this means good call quality is going to have to come at a price, Nissen says. So enjoy VoIP's free lunch. It is not going to last. ●

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Gabrielle Walker has been writing about science since she completed her PhD in Chemistry at Cambridge University in 1992. A self-confessed "nerdette", she has made several trips to the Arctic and Antarctic, including a stint at the South Pole for thirty-one months. Her highly decorated book, *Good and Beautiful*, tells the amazing story of the scientists who tracked down evidence of a global "big freeze" 200 million years ago which may have triggered the emergence of complex life on Earth. She is a contributing editor for *New Scientist*, where she was previously features editor for several years. Gabrielle is currently working on her new book, *Antarctica: A Journey to the Edge of the World*.

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LIMITED SPACE AVAILABLE SO EARLY BOOKING RECOMMENDED.

Heating Earth's crust

From John King

Mike Follows's letter (5 February, p 28) shows a lack of understanding of the subject of crustal expansion first raised by Peter Mockeridge and Nathalie Bugeaud (15 January, p 28). His calculation that global warming will cause heat to penetrate downwards by only 10 millimetres is not worth the envelope it was written on. Thermal conductivity does not work like that, and anyway the Earth's crust is being heated from below. That a NASA spokesman should reject Mockeridge and Bugeaud's entirely reasonable and well-founded thesis only goes to confirm the impression that new ideas do not figure in the agency's current ethos.

Speaking broadly, the crust is in a steady thermal condition, conveying heat upwards from the mantle to the atmosphere, in places via the oceans. But if the temperature of the atmosphere changes, so will the temperature of the rocks at the surface and the thermal gradient throughout the Earth will readjust, over a timescale of centuries.

Mockeridge and Bugeaud's estimate that this mechanism is capable of producing 20 metres of overthrust at tectonic plate margins for a rise of only 1 kelvin has a horrible current relevance given the Asian tsunami, but this effect is probably not going to cause earthquakes where otherwise none would have occurred. Rather, we should expect intervals between earthquakes to be shorter during periods of global warming, and for some time after temperatures stabilise at the surface.

Of course global cooling would generate a similar influence.
Wymondham, Norfolk, UK

Dyslexic drivers

From Jon Finney

I have an IQ of 131. I have just submitted my PhD. I am in the top 2 per cent for linguistic ability in

my age group in the country. However, I spell like an average 12-year-old, read at the speed of an 11-year-old and construct words phonetically like an average 7-year-old. In a word I am dyslexic. Now, it appears, I drive like a drunk, or least like someone who is over the limit (5 February, p 12).

Fortunately, your story included information on the very small group that the results were derived from. Only 6 dyslexics were compared with 11 non-dyslexics. Imagine if such a limited test had been carried out on say 6 women and 11 men or 6 black drivers and 11 white drivers and any such claim for difference had been made. The uproar would have been, quite rightly, deafening.

What surprises me is that data from such a small (dare one say minuscule) group has ever seen the light of day. Before publishing anything of this nature, much more research should be undertaken. Like many dyslexics I have suffered over the years from constant discrimination, as I cannot spell and find reading difficult at times. This new "revelation" will not help this situation.

All I can say is thank you for a reasonably well balanced report and for including the numbers of volunteers used, as this will allow anyone with an ounce of sense to see the ludicrous nature of the conclusions that have been drawn.
Ely, Cambridgeshire, UK

From John Clark

Surely, if this was true, then Jackie Stewart, who is dyslexic, would never have been Formula One world racing car champion.
Leeds, UK

From Susan Parkinson,
Arts Dyslexia Trust

This question highlights the important difference between audio-sequential and visual-spatial thinkers. The first, who are happy relating things according to their position in time, may sometimes react more quickly to road signs. But the second group,

to which most dyslexics belong, are more acutely aware of how things relate in space. Safe driving would seem to demand not only quick reactions but good spatial judgement and an awareness of what is happening on the road ahead.

In fact, the people who lack visual-spatial awareness are likely to be a very much greater danger on the roads than any poor time-keeper, whether dyslexic or not.
Ashford, Kent, UK

Global genebanks

From Tewolde Berhan Gebre Egziagher, Ethiopia
Environmental Protection Authority

Your article on war-ravaged agriculture contained a very clear message on the importance of conserving crop diversity (22 January, p 34). However, such diversity is not only critical in restoring agriculture following natural or human-induced disasters but is the foundation of all sustainable agriculture.

The genetic diversity contained within thousands of traditional varieties, now being abandoned

housed in gene banks throughout the world – facilities that are meant to be safe havens – are themselves under threat, not only through wars and other disasters but also through years of underfunding and neglect.

In October last year a new financing mechanism, the Global Crop Diversity Trust, came into being with the specific objective of salvaging the world's most important collections and ensuring their continued availability. Initiated by the UN Food and Agriculture Organization and the Consultative Group on International Agricultural Research, the Trust seeks to spend approximately \$13 million per year from an endowment of \$260 million to ensure the survival of the world's most important genetic resources in perpetuity.

Ethiopia may be one of the poorest countries in economic terms, but it is one of the richest in crop diversity. Ethiopia recognises the magnitude of its responsibility to the whole of humanity for conserving its immense agricultural biodiversity, and has pledged its financial support to the trust. Ethiopia calls on other governments, foundations, corporations and individuals to join it in this effort.

Addis Ababa, Ethiopia

Selfish harmony

From John Humbach

On the question of maintaining harmony on deep space missions, as raised by lone explorer Gilles Elkaim (8 January, p 44), readers may like to know how the three-man crews of remote lighthouses used to keep up their morale.

Each man had his own supplies, down to the last matchbox and packet of sugar, all marked with its owner's name. Cooking was by roster but the man responsible was expected to prepare three different meals, according to individual preferences and supplies. There was no lending, borrowing or giving at any time – except,



by farmers but conserved in gene banks around the world, represents one of humanity's most valuable resources and gives hope that we will be able to feed ourselves in the future in the face of uncertain climates, new pests and diseases and changing market demands.

Yet many of the collections



presumably, in an emergency.

Long experience had shown that this practice was the only way to guarantee harmonious relationships in a small crew, isolated for long periods with no hope of rapid physical contact with the mainland, at least until helicopters became available.

Today, of course, all rock lighthouses are automated and have a helicopter platform on top – but the experience gained on them might be relevant to deep space voyages.

Etchinghill, Kent, UK

Religious road sense

From Mark Harvey

The findings about Orthodox Jews as pedestrians will come as no surprise to anyone who has worked and lived in many countries outside western Europe and the US (22 January, p 16). Whether it is Allah who protects some, or a more fatalist understanding to be found in South Asia, the challenge of managing the interaction between pedestrians and vehicles is huge. But let this not be a one-sided argument that “pedestrians must behave more responsibly”. I interpret South Asian behaviour as a healthy disrespect for those who consider the car as god.

The Global Road Safety Partnership, set up by the World Bank, has a lot to offer in deeper understanding. Meanwhile, it is the poor and pedestrians that lose out in transport policy.

Kathmandu, Nepal

Meaningless image

From Edmond Wright

I should like to point out that Kevin O'Regan's claim that we do not experience colour inside our brain and that, therefore, all our experience is perceptual, has not gone unchallenged (29 January, p 40). As I pointed out in a commentary in *Behavioural and Brain Sciences*, where he and Alva Noë put forward this view, it makes the error of ignoring the patently empirical fact of internal sensation.

Take this example: a little girl aged five experiences an after-image. She does not know that it is an after-image – indeed she experiences it for a moment or so without actually paying it any attention. However, happening to close her eyes, she does come to notice it, but only as a meaningless splodge among other meaningless splodges.

But after a second or two, she notices that it is in a hexagonal shape. In this same instant she realises that her mother has brought her up her favourite sweet as she usually does, and that it is on the silver hexagonal dish that she usually brings it on, and that she has placed it on the window sill in the bright sunlight. So at last she has perceived with the aid of her sensation. She opens her eyes and goes and gets the sweet, that before she had not realised was there.

Unfortunately for O'Regan's thesis that there is no such thing as internal sensation without attendant perception, here we have a counter example, for the child first experienced internally a “raw-feel” sensation (for everyone admits that after-images are not in the external world), then noticed it, still as meaningless, then at last used her perceiving mode to project upon that internal experience an “objective” interpretation.

If this is possible for after-images, there is nothing to prevent us claiming the same structure for ordinary open-eye visual sensation: that it is

fundamentally meaningless, internal, and open to experimental changes of perception.

Cambridge, UK

From Ian Jackson

Your article described a blind person “seeing” via a tactile pad on the tongue. It is good to see this development in real life. I first read about this concept in the science fiction story *The Persimmon Sequence* published 34 years ago by Don J. Fretland, where a compact head camera and tactile pad was used by a blind character to “see” basic shapes at low resolution. The only significant difference in the story is that the tactile matrix pad was strapped to the inside of the upper thigh and provided feedback through skin sensitivity.

Drouin West, Victoria, Australia

Adult AI

From Ben Haller

Michael Witbrock believes that “the web will ultimately make it possible for computers to acquire



a very detailed knowledge base” (29 January, p 21). If he is right, then the first artificial intelligence humanity ever creates will know an awful, awful lot about porn.

Menlo Park, California, US

Scottish bikes

From Alexander Kennedy

Mick Hamer describes enthusiasm in the bicycle as not

being revived until Parisians showed an interest in the 1860s (29 January, p 48), but he omitted to mention the Scottish contribution in the 1840s. In 1842, Kirkpatrick Macmillan, a Scottish blacksmith, devised and built a treadle-driven bicycle.

This was sufficiently efficient for him to be able to ride it from his home at Courthill Smithy at Keir Mill in Dumfries to Glasgow, a distance of over 90 kilometres. There he had the distinction of having one of the first recorded cycle accidents when he collided with a little girl who strayed into his path. British cyclists regard Macmillan as the originator of the modern bicycle and his name is celebrated to this day.

It is very relevant that Karl Drais's invention was prompted by the high cost of oats for feeding horses. We may yet be driven back to the bicycle by the increasing price of petrol and diesel oil.

Sheffield, UK

For the record

● In the interview with Barry McSweeney (29 January, p 44), it was stated that a group of senior staff at the European Commission's Joint Research Centre had been fired. In fact, they had changed responsibilities as part of the reorganisation of the JRC and have significantly contributed to developing it as an important European policy support body. Our apologies for the error.

● The Liverpool vaccine plant mentioned in our news item about a glut of flu vaccine (5 February, p 14) is now run by Chiron, not GlaxoSmithKline as stated.

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India

- 33 Going it alone** The space programme that survived international sanctions
- 36 By the people, for the people** Genetically modified crops don't just come from multinational corporations
- 38 Silicon subcontinent** India is becoming the place to be for cutting-edge research
- 40 Right here, right now** Bangalore's young IT crowd has it all
- 41 Make it pay** R.A. Mashelkar is campaigning for a new way of thinking
- 42 Vaccines for pennies** The bankers said it couldn't be done
- 43 Dishes to savour** Why astronomers are flocking to India's wine country
- 44 Voyage of discovery** Drug companies are risking everything to stay afloat
- 47 We have to take risks** Shobo Bhattacharya, director of the Tata Institute for Fundamental Research, on India's unique science culture
- 48 Daring to be different** India has bold plans for a nuclear future
- 50 Sight for sore eyes** A Hyderabad hospital is pioneering a stem-cell cure for blindness
- 52 Reinventing India** Nandan Nilekani, CEO of Infosys, on what it took to build a billion-dollar software company
- 53 Welcome to the global village** The internet has arrived in Pinjavakkam



The next knowledge superpower

 THE first sign that something was up came about eight years back. Stories began to appear in the international media suggesting that India was “stealing” jobs from wealthy nations – not industrial jobs, like those that had migrated to south-east Asia, but the white-collar jobs of well-educated people. Today we know that the trickle of jobs turned into a flood. India is now the back office of many banks, a magnet for labour-intensive, often tedious programming, and the customer services voice of everything from British Airways to Microsoft.

In reality, the changes in India have been more profound than this suggests. Over the past five years alone, more than 100 IT and science-based firms have located R&D labs in India. These are not drudge jobs: high-tech companies are coming to India to find

innovators whose ideas will take the world by storm. Their recruits are young graduates, straight from India's universities and elite technology institutes, or expats who are streaming back because they see India as the place to be – better than Europe and the US. The knowledge revolution has begun.

The impact of the IT industry on the economy has been enormous. In 1999 it contributed 1.3 per cent of India's GDP. Last year that figure had grown to 3 per cent. And what's good for one science-based industry should be good for others. India has a thriving pharmaceutical industry which is restructuring itself to take on the world. And biotech is taking off. The attitude is growing that science cannot be an exclusively intellectual pursuit, but must be relevant economically and socially. The hope among some senior scientists and officials is that India can short-cut the established path of industrial development and move straight to a knowledge economy.

For the *New Scientist* reporters who have been in India for this special report, many features of the country stand out. First, its scale and diversity. With a population of more than a billion, the country presents some curious contrasts. It has the world's 11th largest economy, yet it is home to more than a quarter of the world's poorest people. It is the sixth largest emitter of carbon dioxide, yet hundreds of millions of its people have no steady electricity supply. It has more than 250 universities which catered last year for more than 3.2 million science students, yet 39 per cent of adult Indians cannot read or write.

These contrasts take tangible form on the outskirts of cities from Chennai to Delhi, Mumbai to Bangalore. Here, often next to poor areas, great gleaming towers of glass are growing in which knowledge workers do their thinking. These images of modernity are a far cry from stereotypical India – a place bedevilled alternately by drought and flood, of poor farmers and slum-dwellers. Yet both sets of images are real – and many others besides.

High-tech is not the sole preserve of the rich. Fishermen have begun using mobile phones to price their catch before they make port, and autorickshaw drivers carry a phone so that customers can call for a ride. Technology companies are extending internet connections to the remotest locations. Small, renewable electricity generators are appearing in villages, and the government is using home-grown space technology to improve literacy skills and education in far-flung areas.

These efforts are often piecemeal, and progress is slow. “Illiteracy today is

High-tech meets low-tech at the Motorola building in Bangalore



"Why spend large sums on moon rockets and telescopes when India still struggles to feed millions of its citizens? Because without science poverty will never be beaten"

reducing only at the rate of 1.3 per cent per annum," says R. A. Mashelkar, director-general of the government's Council of Scientific and Industrial Research. "At this rate, India will need 20 years to attain a literacy rate of 95 per cent." He is hopeful that technology can speed up this process.

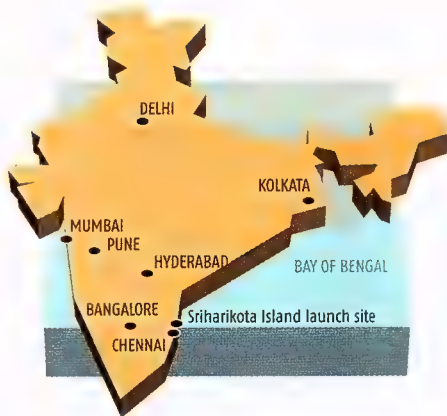
Science too has its role to play. Critics of India's investment priorities ask why the country spends large sums on moon rockets and giant telescopes while it is still struggling to find food and water for millions of its citizens? The answer is that without science, poverty will never be beaten. "You cannot be industrially and economically advanced unless you are technologically advanced, and you cannot be technologically advanced unless you are scientifically advanced," says C. N. R. Rao, the prime minister's science adviser.

Rise of the middle class

The knowledge revolution is already swelling the ranks of India's middle class – already estimated to number somewhere between 130 million and 286 million. And the gulf in spending power between the poor and the comfortably off has never been more apparent. Take cars. Sales are rising at more than 20 per cent a year. Before India opened up its economy in the early 1990s, only a few models were available, almost all home-built. Today, top-end imported cars have become real status symbols. Another consequence of the

knowledge revolution is that the extreme wealth of a new breed of young, high-tech yuppies is challenging traditional gender roles and social values.

Whether the new-found prosperity and excitement of present-day India can be sustained will depend crucially on how the government guides the country over the next few years. Cheap labour and the widespread use of English do not guarantee success, and there are major obstacles that the country will need to tackle to ensure continued growth. Take infrastructure. Where China has pumped billions into water, road and rail projects, India has let them drift. Likewise, companies



complain that bureaucracy and corruption make doing business far more difficult than it ought to be.

One of the critical issues facing India is the gulf between the academic world and industry. The notion that scientific ideas lead to technology and from there to wealth is not widespread. This stems in large measure from the attitudes prevalent before 1991. Before economic liberalisation, competition between Indian companies was tame, so they were under no pressure to come up with new ideas, nor did academics promote their ideas to industry.

India's attitude to patents are a product of that mindset. The country has no tradition of patenting, and only recently have institutions and academics started spinning off companies and filing for patents in earnest. Most applications filed in India still come from foreign companies. Until this year, the country did not recognise international patent rules, a failure that hampered interactions with foreign companies.

The suspicion remains that Indian companies are out to steal ideas, says Gita Sharma, chief scientific officer of Magene Life Sciences, a start-up company in Hyderabad. "We are not yet able to wipe away that image." And while India has now adopted those international rules on paper, there are still concerns about how strictly they will be enforced. "It will take a couple of years before the full implications play out," says Sankar

Krishnan, a biotechnology analyst for McKinsey and Company in Mumbai.

Bringing research round to a more commercial way of thinking is not the only issue that academia must face up to. Another cultural problem, according to some scientists, is that too often institutions have an ethos of playing safe. Researchers who devise and test daring theories are criticised if they fail, discouraging the kind of ground-breaking research that India needs.

There is a widespread view that the entire university system needs an overhaul. India awards only 5000 science PhDs a year, says Mashelkar, yet it should be producing 25,000. There are funding problems and political interference in the running of some universities, particularly those run by state governments. In response, central government has decided to select 30 universities, give them extra money, and mentor and monitor them to create a series of elite institutions.

But such changes will be for nothing if students choose not to study science. In recent years, increasing numbers have chosen to study IT and management because that's where money is to be made. "IT and outsourcing has improved the economy and quality of life of people, but has had a negative effect on science," Rao says. Mashelkar hopes that as science-based companies grow, and demand for fresh blood increases, salaries will rise and more students will opt for science.

Chasing China

These problems must be solved if India is to capitalise on its recent gains, and there are hopeful signs that Indian science is improving in the global scheme of things. Its share of the top, highly cited publications has increased, but it is starting from a very low base. The government spends only \$6 billion a year on research and it still has fewer scientists per head of population than China or South Korea.

India's greatest rival has always been its giant neighbour to the north. While IT and services are helping India log 6 per cent year-on-year increases in GDP, China's vast manufacturing base is raising its GDP by around 9 per cent a year. Even in India's strong suit of knowledge-based industries, China could still steal the march on it, not least because its Communist government can command change, while in India the democratic government can only guide national development.

Nevertheless, the rewards for India of a thriving science-based economy could be huge. The investment bank Goldman Sachs estimates that if India gets everything right it will have the third largest economy in the world by 2050, after China and the US. India is not yet a knowledge superpower. But it stands on the threshold. ●

Going it alone

The space programme that survived sanctions

India's first rocket to reach geosynchronous orbit launched in 2001

 NESTLED amid the eucalyptus, cashew and coconut trees of Sriharikota Island on the eastern coast of India, north of Chennai, is a 76-metre steel tower. If all goes to plan, some time in late 2007 the tower will be engulfed in flames as India's first mission to the moon blasts off. Sriharikota will also be the launch site for India's most advanced scientific research satellite, Astrosat. The satellite will measure, among other things, X-ray radiation emitted by matter sucked into black holes and given off at the birth and collision of stars.

But why is India, a country that still has so many development problems on the ground, aiming for the heavens? To Indian scientists, the question is not only patronising of their scientific aspirations, it betrays an ignorance of the Indian space programme's greater purpose and successes against the odds.

India's political leaders say the country cannot afford not to have a space programme. Indira Gandhi, who was India's longest-serving prime minister, believed it was not only important for science, but also vital to India's development.

Take, for example, India's six remote-sensing satellites – the largest such constellation in the world. These monitor the country's land and coastal waters so that scientists can advise rural communities on the location of aquifers and where to find watercourses, suggest to fishermen when to set sail for the best catch, and warn coastal communities of imminent storms (see "Eyes in the sky", page 35). India's seven communication satellites, the biggest civilian system in the Asia-Pacific region, now reach some of the remotest corners of the country, providing television coverage to 90 per cent of the population. The system is also being used to extend remote healthcare services and education to the rural poor.

But it has been a long time coming. When India first detonated a nuclear device in 1974, the US and European nations imposed widespread sanctions to restrict India's access to technologies that could be used to make a nuclear missile. This hobbled the country's rocket development programme and forced the Indian Space Research Organisation (ISRO) to reinvent technologies it could no longer buy. In the long run this has given India an advantage over other countries with aspirations to reach space. Its space programme is ►



"India's first rocket, the Satellite Launch Vehicle, ended up crashing into the Bay of Bengal 5 minutes after launch"

already largely self-sufficient and aims to soon be completely independent of foreign support.

It hasn't all been plain sailing. Its first rocket, the Satellite Launch Vehicle, ended up crashing into the Bay of Bengal 5 minutes after launch in 1979. The following year it placed a 40-kilogram remote-sensing satellite into near-Earth orbit, but the satellite's perigee was lower than planned and it entered the atmosphere and burnt up after only 130 orbits. The Augmented Satellite Launch Vehicle followed, and in 1992, after two crashes, it finally succeeded in lifting 150 kilograms to a height of 435 kilometres.

ISRO moved on to the Polar Synchronous Launch Vehicle, designed to carry 1-tonne satellites to a height of nearly 1000 kilometres. Though the first launch in September 1993 crashed, the PSLV has since performed flawlessly, placing seven Indian satellites and four from other countries into orbit. "It is our workhorse," says Madhavan Nair, director of ISRO. In 2003 the rocket was used to launch India's latest remote-sensing satellite, IRS-P6, capable of imaging the

Earth's surface to a resolution of 5 metres.

To put its heavier communications satellites into geostationary orbit, India still has to rely on foreign hardware. But that may soon change. ISRO's latest rocket, the Geosynchronous Launch Vehicle (GSLV) is able to lift large satellites into geostationary orbit, 36,000 kilometres up. On 20 September 2004, the GSLV launched the 2-tonne EDUSAT, the world's first satellite dedicated to providing support for educational projects.

One of the GSLV's rocket boosters is a Russian-made cryogenic engine. International sanctions meant India was only allowed to buy engines, not the know-how to design and build them. So for future rockets ISRO engineers are developing their own. Ground tests have been completed and the plan is to launch a completely home-made GSLV-Mark 2 by the end of this year, Nair says.

ISRO is already planning the next-generation GSLV, the Mark 3, which will be powerful enough to launch India's biggest satellites. Nair now has his sights on the commercial market. A launch on GSLV-Mark 3

ROCKETING EVOLUTION

In a little over 30 years from struggling to lift off, India will soon head to the moon

50 metres

40

30

20

10

0



Satellite Launch Vehicle

First launch in 1979 failed. Second launch in July 1980 successfully placed imaging satellite into orbit



Augmented Satellite Launch Vehicle

First two launches in 1987 and 1988 failed. Only two further launches, placing scientific experiment satellites into orbit in 1992 and 1994



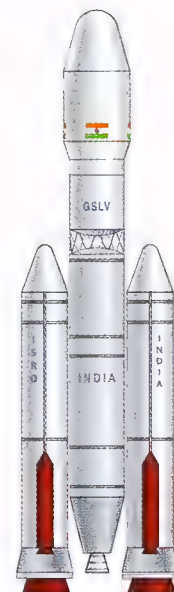
Polar Satellite Launch Vehicle

First launch in 1993 unsuccessful. Between 1994 and 2003 seven successful launches placed imaging and experimental satellites into orbit



Geosynchronous Satellite Launch Vehicle

First flight in 2001, two more in 2003 and 2004 placed commercial satellites in orbit. Mark 2 with Indian-designed engine



Geosynchronous Satellite Launch Vehicle

India's most powerful rocket to date. Due for launch by end of 2007

Height
Weight
Fuel
Payload weight
Orbit

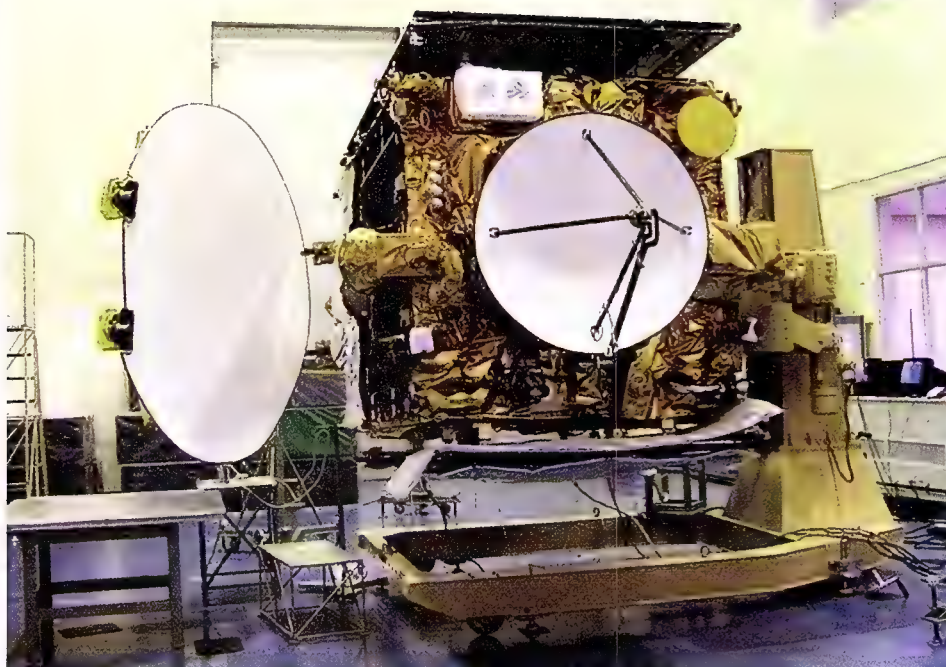
SLV
22m
17 tonnes
Solid
40 kg
Low Earth (300-900 km)

ASLV
23.5m
39 tonnes
Solid
150 kg
Low Earth

PSLV
44.53 m
294 tonnes
Solid & liquid
1400 kg
Polar synchronous

GSLV MK-1 and 2
49m
414 tonnes
Solid, liquid & cryogenic
2000 kg
Geostationary

GSLV MK-3
42.4m
629 tonnes
Solid, liquid & cryogenic
4000 kg
Geostationary



Communications satellite
EDUSAT before it was
launched last September

Eyes in the sky

THOUGH Astrosat and the moon mission are the headline-grabbers, using imaging satellites for development remains at the top of the agenda for the Indian Space Research Organisation (ISRO).

For instance, when the skies are relatively clear between January and March, infrared images are used to measure the reflectance of plant-covered surfaces to check how well watered the crops are. It is also possible to distinguish between crops such as rice, wheat and cotton, and even predict whether a crop might fail for lack of water. "We are able to forecast the yield one month before the harvest," says Venkatakrishna Jayaraman, the director of ISRO's Earth Observation System. In this way the government can be forewarned of possible food shortages.

Ensuring a supply of clean drinking water is a problem in many parts of rural India. Villagers often resort to guessing the right spot to drill a well based on experience, but it is a hit-and-miss affair. Topographic and hydrological maps produced from satellite images allow Jayaraman's team to help rural communities locate areas most likely to yield underground water. "The success rate for drilling wells has gone up from 45 to 90 per cent," says Jayaraman.

The next step for Jayaraman's team is to use the same information to work out where to build small dams to capture rainwater and recharge underground reservoirs. This approach could help reclaim arid and semi-arid land for agricultural use.

ISRO's satellites are also having an impact at sea. OCEANSAT, launched in 1999, monitors the chlorophyll content of oceans and the sea surface temperature. ISRO scientists use the information to identify areas where cold, nutrient-rich water wells

up from the ocean floor, which in turn attract fish.

The coordinates of these areas are then sent to more than 200 coastal centres. The upwellings last for several days – meaning the areas identified contain high concentrations of fish – long enough for fishermen to arrive and gather a sizeable catch. According to Jayaraman, fish catches have doubled in the last decade.

Besides remote sensing, ISRO operates eight communications satellites. These are now used by 35,000 commercial customers, all based in India. "If we didn't have the satellites, they would have gone and hired a satellite from somewhere else," says Appana Bhaskarnarayana, director of ISRO's satellite communications programme.

ISRO has also used these satellites to implement disaster-warning systems. In 1977 a cyclone killed 10,000 people on the coast of Andhra Pradesh in south-east India. In the 1990s data from meteorological satellites was used to warn of a similarly devastating cyclone, dramatically reducing the loss of life to 900. "The technology has helped to predict cyclones maybe a few hours in advance," says Bhaskarnarayana. "Lots of lives have been saved."

ISRO is becoming more ambitious in how it plans to use these satellites. It has already linked 69 hospitals in remote areas of India such as the Andaman Islands to 19 hospitals in India's main cities. A health worker in a remote location can then transmit a patient's medical information to a specialist in seconds and, in many cases, a video consultation is sufficient for diagnosis. This means the patient can avoid travelling huge distances unless it is absolutely necessary.

"The moon probe will map the lunar surface at resolutions down to 5 metres, something that has never been done before"

should cost about half the rate charged by France, the US and Russia, he says.

India's space programme is already a money-earner. ISRO sells infrared images from its remote-sensing satellites to other countries, including the US, where they are used for mapping. And the Technology Experiment Satellite, launched in October 2001, is beaming back images of the Earth's surface with a resolution of 1 metre, though they are not yet available commercially.

Three per cent of ISRO's \$3.3 billion 5-year budget is devoted to the planned moon mission. A reconfigured PSLV rocket will lift Chandrayan – "moon vehicle" in Hindi – to 36,000 kilometres, after which the craft's own engines will take it to the moon. Nair says one of the purposes of the mission is to inspire Indian youngsters to take up a career in science.

Chandrayan will create 3D maps of the moon's surface at a resolution of between 5 and 10 metres, something that has never been done before. It will also map the distribution of ilmenite, a mineral that traps helium-3, a possible source of energy for future bases on the moon. No manned missions are planned, but if the trip is successful, robots might be sent up to collect samples.

According to Nair, the Madras School of Economics in Chennai has estimated that ISRO's projects have added between two and three times the organisation's budget to the nation's GDP. Several countries in Africa and Asia are seeking ISRO's help to emulate the model. "India is perhaps the only country where societal needs are met by the space programme in a cost-effective manner and the services are reaching the needy," says Nair. **Anil Ananthaswamy** ●

By the people, for the people

Genetically modified crops don't just come from big corporations

 "WESTERN protesters holding a cup of Starbucks have no business protesting against GM," says Kiran Sharma. Rich Europeans can afford to reject the technology, he says, "here, we don't have a choice."

Sharma believes passionately that GM crops can go a long way towards tackling hunger in the developing world. But he is no Monsanto stooge. Sharma is a scientist at the International Crops Research Institute for the Semi-Arid Tropics in Hyderabad, southern India. ICRISAT is a network of non-profit research institutes in developing countries, funded by donations from rich nations and international agencies.

GM succeeds where conventional breeding cannot, says Sharma, because it can produce traits, such as disease resistance and drought tolerance, that do not exist in a crop or its wild relatives. Bringing in genes from other species is the only way to improve these crops. "We are trying to give breeders something they don't have," he says.

India embraced GM in March 2002 when the government's Genetic Engineering Approval Committee gave the green light for three varieties of Bt cotton. The crops, owned by a Monsanto subsidiary called the Maharashtra Hybrid Seed Company

"Kiran Sharma says GM technology allows him to beat diseases that traditional breeding has failed to tackle"

(MAHYCO), have an added bacterial gene for a toxin that kills a major caterpillar pest called the American bollworm (*Helicoverpa armigera*). So far, Bt cotton is the only GM crop grown commercially in India.

Advocates of Bt cotton say it lets farmers use less pesticide – typically one or two sprays per harvest as opposed to three or four sprays for conventional varieties. They argue this makes it cheaper and more environmentally

friendly because the Bt toxin only kills moth and butterfly caterpillars. But no one has studied in detail the effect of the crops on non-target insects and other species.

MAHYCO claims the GM crop typically yields around 30 per cent more than non-GM crops, but critics dispute this. Suman Sahai is organiser of the anti-GM group Gene Campaign in New Delhi. She and colleagues studied 100 farming families growing GM and non-GM cotton in the states of Maharashtra and Andhra Pradesh. According to Sahai, yields of the non-Bt variety actually beat the GM crop by around 16 per cent, although the published results do not offer any figures to back up this claim.

Certainly that finding doesn't tally with the crop's popularity. "Farmers have bought it left and right," says Govindarajan Padmanaban, a biotechnologist at the Indian Institute of Science in Bangalore. "Farmers are cleverer than the activists or the companies. They won't buy things if they do not work."

Sahai's main objection is that embracing GM will hand over control of India's food supply to multinational companies that are motivated by profit rather than the best interests of farmers and consumers. "They have nothing in the pipeline that is targeting the poor," she says. "The public is completely excluded from the decision-making process." Why gamble on a potentially dangerous technology with economic risks, she asks, when old-fashioned selective breeding has served so well.

Sharma says GM technology allows him to beat diseases that traditional breeding has failed to tackle, such as clump virus and rosette virus, which infect groundnut plants. He is also working on a "golden" groundnut variety which manufactures extra vitamin A for a more nutritious crop. Sharma is now conducting small-scale field trials of GM groundnut, pigeon pea and chickpea engineered at ICRISAT (see "Staple crops go GM").

The chickpea and pigeon pea are both genetically engineered to contain a Bt toxin gene. Sharma began by producing lots of GM varieties differing from one another in



Bt cotton is so far the only GM crop grown commercially in India



SHARAD KUMAR

the position of the inserted gene in the genome. This can affect how strongly the gene is expressed and how well it is transmitted to the next generation. Then he narrowed down the initial versions to the handful he is field-testing.

The aim of his present field trials is to discover which versions work best outdoors before moving on to large-scale trials in farmers' fields. Both chickpea and pigeon pea are naturally drought resistant and are widely grown for food by subsistence farmers. Ultimately, Sharma intends to distribute the GM seeds to farmers for free.

GM research only takes up around 10 per cent of the research at ICRISAT, but the researchers there feel they have a special contribution to make because they cannot be seen as being in the pocket of industry. "We see ourselves as the acceptable face of GM," says ICRISAT's deputy director-general, Dyno Keatinge.

There is an expectation among researchers that opposition to GM crops will melt away once their home-grown research begins to deliver tangible results. India's farmers are already voting for Bt cotton by buying the seed. GM crops that are "Made in India" can only get more popular. **James Randerson** ●

Staple crops go GM

ICRISAT's palatial campus is an oasis of serenity after the noisy streets of Hyderabad. As Kiran Sharma drives me through part of the 1400-hectare site we pass fields of diminutive chickpea and pigeon pea plants next to imposing stands of pearl millet and sorghum. This haven, a half-hour drive from central Hyderabad, is home to 278 wild bird species, as well as monkeys and, slightly alarmingly, cobras. But I am here to see something that could change Indian agriculture.

Sharma stops the car next to a low fence. Within the small enclosure are rows of unimpressive-looking, knee-high plants. And in a central inner sanctum of netting designed to keep insects out are the world's first field tests of varieties of pigeon pea (*Cajanus cajan*). They have been genetically modified with the Bt gene, Sharma announces.

In an enclosure next door is a patch of bare earth, where Sharma tells me he planted another world first only the day before, Bt chickpea (*Cicer arietinum*). Both plants are grown primarily by poor subsistence farmers, but the conventional varieties are vulnerable to the American bollworm (*Helicoverpa armigera*), a caterpillar that can wipe out more than half a farmer's harvest. "These products are badly

needed by subsistence farmers," says Sharma.

The non-GM plants in the outer enclosure act as a pollen trap: a way to find out if they pick up the inserted gene from plants in the inner sanctum and pass it to their offspring. They and the earth around them could be contaminated with GM pollen, so I am not allowed near them in case I then contaminate conventional varieties growing nearby.

Sharma's most advanced GM crop is a variety of groundnut (*Arachis hypogaea*) that is resistant to peanut clump virus, which can reduce harvests by 70 per cent. His team has inserted a gene for part of the virus's protein coat. The plants express the protein but do not fold it correctly, and for reasons Sharma is not yet sure of, this defective protein stops the virus from assembling its coat and escaping to infect other cells.

Groundnut is a particularly good candidate for genetic modification because it is almost entirely self-fertilised, so there is little chance of the foreign genes escaping. What's more, growing GM groundnut should benefit conventional growers in the area because the plant mops up virus particles in the soil. "Our transgenic plants are eliminating the virus," says Sharma. **James Randerson**

Silicon subcontinent

India is becoming the place to be for cutting-edge research

Bangalore's overburdened infrastructure isn't deterring IT companies

 **TRAFFIC** in Bangalore is now bumper-to-bumper just about everywhere and gridlock is a certainty during rush hour. A journey from the centre to the hub of the IT industry on the city's outskirts that took only 20 minutes a few years ago can now take two hours. Corporate limos jostle with autorickshaws, trucks, taxis and even vegetable vendors with pushcarts plying the day's produce. The city is choking under the influx of companies, both foreign and Indian, eager to partake of its seemingly inexhaustible supply of cheap programmers.

And there's little respite in sight for Bangalore's creaking infrastructure. You'd think companies would be starting to have qualms about opening new offices in the city. Think again. Some of the biggest names in IT are heading towards Bangalore once more, and this time round it's not cheap labour they are looking for. They are hunting down the brightest, most inventive minds in India to populate a swathe of cutting-edge research facilities.

The work being done in these labs rivals any in the US and Europe. Ajay Gupta, director of Hewlett-Packard's research labs in Bangalore, says India is the place to be. "HP sees its India lab as being on an equal footing with our other research labs worldwide," he says.

Things have moved on a long way in the 20 years since US chip giant Texas Instruments opened an office in Bangalore to crank out software for testing and verifying TI's chip manufacturing processes. Take the \$80 million multidisciplinary centre set up by General Electric to serve the US company's research needs. The centre is GE's first and largest R&D lab outside the US. It has 2300 employees, 60 per cent of whom have a master's or PhD degree in science. Anything is fair game here – from plastics to turbines to molecular modelling. "We are not here to serve the Indian market, but to serve [GE's] global research agenda," says Guillermo Wille, managing director of the company's lab in Bangalore and the only non-Indian on site. The products of research done at the labs are purely for export.

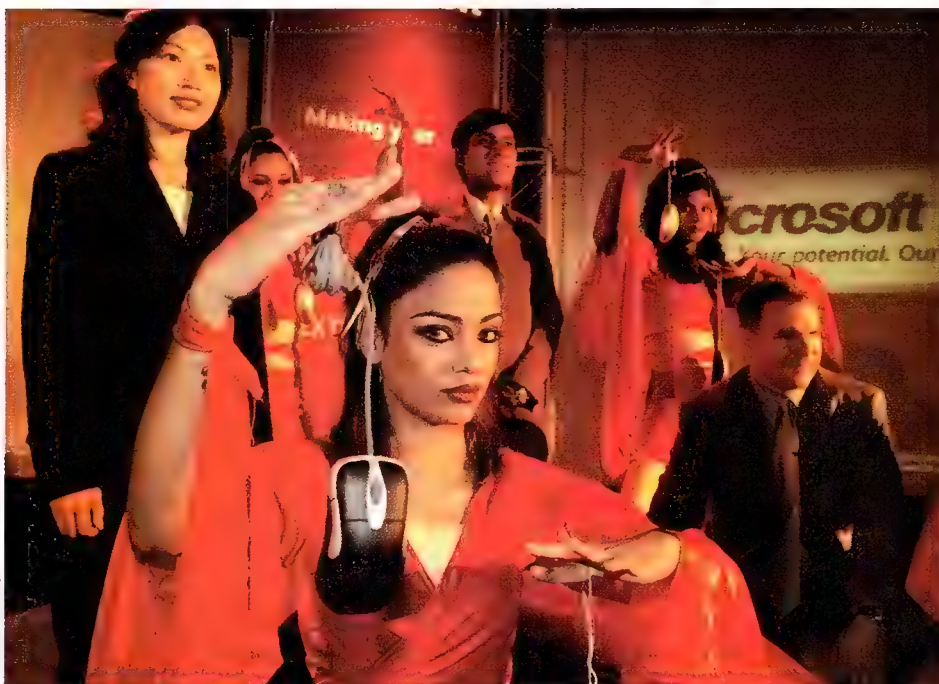
Using techniques such as numerical analysis and computational fluid dynamics, the GE researchers have significantly improved the efficiency of the company's wind turbines and its engine for Boeing's planned 7E7 airliner. The centre is renowned for its materials science division, which invented a resin co-polymer that has made possible self-destructing CDs and DVDs. The discs are sold in sealed pouches: break the seal and the polymer reacts with air, making the disc unreadable 48 hours later. More

mundane but no less significant is a water-saving washing machine also invented there.

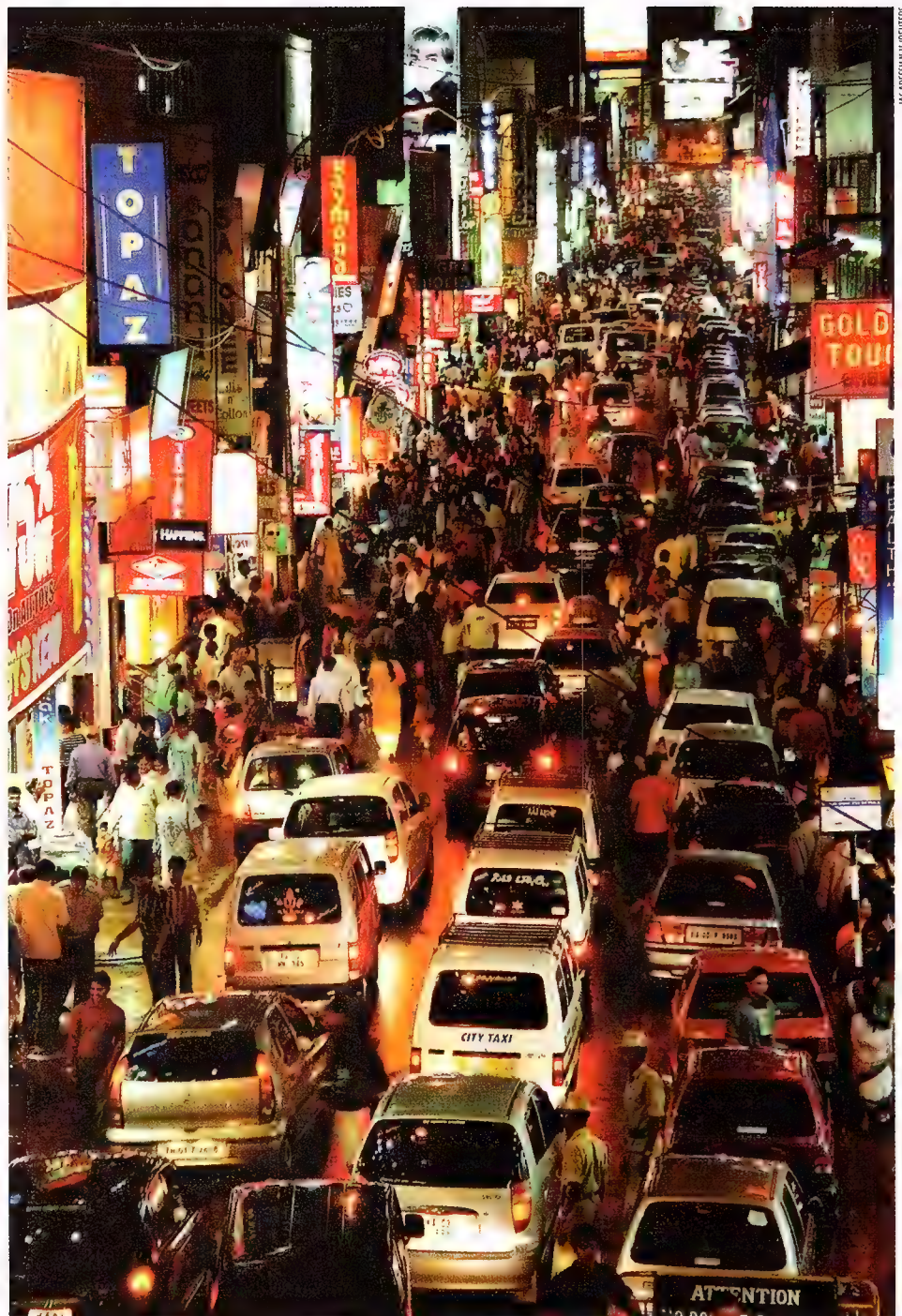
Another high-profile firm to set up shop in Bangalore is Google, the California-based company whose name has become synonymous with internet searching. Krishna Bharat, co-founder of Google Labs India and inventor of Google News, is looking for top PhD graduates from Indian universities to augment the dozen or so researchers working in Google's largely empty two-storey office in Bangalore, which opened last year. Bharat's team will research ways to improve internet searching in Indian languages and work on voice interfaces and other alternatives to the keyboard and mouse. Bharat expects his centre will soon contribute to Google's global research effort. Other high-tech giants that have opened research labs in Bangalore include Cisco, Intel, Sun Microsystems and Motorola.

While many of these companies' developments are intended for application worldwide, Hewlett-Packard's approach is different. Its Bangalore research centre, opened in 2002, has the express purpose of applying local brains to local problems. "The poorer people in countries like India aren't served by existing technology, so we need to find new technologies for them," Gupta says.

Microsoft is one of the latest IT giants to open a research centre in India



"The biggest names in IT are hunting down the most inventive minds to populate their research labs"



"At last count, Bangalore had more than 150,000 software engineers, the kind of numbers only Silicon Valley can boast"

His team is exploring new ways of making the internet accessible to non-English-speakers, and they have invented a Hindi language keyboard to cater to a majority of the non-English-speaking Indians. The lab has also developed a cheap touch-sensitive pad-based system to write emails. The text is digitised as you write and sent as an attachment to a normal email. "It opens up the possibility for people who are intimidated by keyboards to communicate via email," says Gupta.

Microsoft joined the party this year, with a research centre in Bangalore also intended to address the needs of India and other Asian markets, such as developing

Indian-language versions of its software.

Companies are choosing Bangalore for one main reason: the availability of good computer-science professionals. "We weren't able to hire enough good-quality engineers in Silicon Valley," Bharat says. The concentration of high-tech companies in the city is unparalleled almost anywhere in the world. At last count, Bangalore had more than 150,000 software engineers – approaching the kind of numbers only Silicon Valley can boast.

As well as being a hotbed of computing expertise, Bangalore has significant scientific talent, especially in physics and materials

science. It is this that companies such as GE have come to Bangalore for, along with Indian researchers' mathematical skills in analysis and modelling. "They spend as much time in front of the computer as they do in the wet lab," Wille says.

Though Bangalore is the main focus for high-tech in India, it is not the only one. Other cities are vying for a piece of the research pie. IBM, for example, set up its labs on the campus of the Indian Institute of Technology in New Delhi in 1998, and now employs 100 researchers. Besides contributing to global projects such as the WebFountain web search engine, the centre invented a comprehensive voice-to-text recognition system that translates from Indian-accented English and Hindi into text in the respective language. "It's only on rare occasions like with the speech recognition system that our work has application only in India. Generally we try to build generic solutions that apply globally," says Ponani Gopalkrishnan, director of IBM's Delhi labs.

Though foreign multinationals have dominated the research agenda in India till now, a growing number of Indians who have worked abroad are returning home with cash, contacts and confidence to set up companies of their own. Mouli Raman, co-founder of Bangalore start-up OnMobile says, "For the first time, Indians who have been exposed to the world realise they can do something just as good. They believe they can be world-class." **David Cohen** ●

Right here, right now

India's young IT crowd has it all

 SOUVIK DAS draws on his cigarette, sips his Bacardi and lime, and sits back to survey the nightlife below. We are sitting on the balcony in a bar called the 13th Floor, one of Bangalore's hippest hangouts but until recently the preserve of ageing businessmen and local celebrities. The place is now frequented by a new clientele – Bangalore's "IT crowd", the young, high-earning men and women who work in the city's booming technology companies.

Most are in their 20s and, like Das, can easily afford to pay the \$5 entrance fee and \$4 for a drink to taste their own version of a Manhattan skyscraper retreat. "I come here quite often to relax after work and get away from the crowds," Das says. Young people like him have drastically changed Bangalore's demographic make-up, from a city of pensioners and retired couples to a vibrant metropolis with expensive brands on every billboard and malls springing up in every neighbourhood.

Time was when most highly educated graduates headed west, mainly to the US. "There were simply no opportunities for clever graduates," says Timothy Gonsalves, a lecturer in computer science at the Indian Institute of Technology in Chennai. That has changed, and the change is most visible in Bangalore.

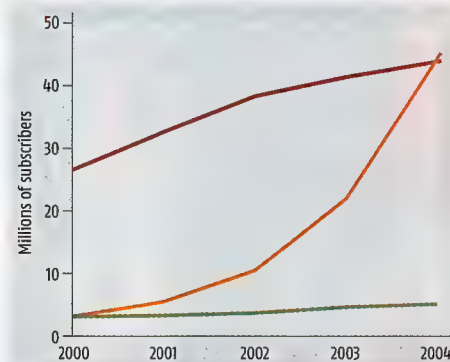
Das is typical. He is 25, and earns about 37,500 rupees per month (about \$850) as head of a team of financial analysts for Reuters. He owns his apartment and sees no reason to leave India. "I think India is a great place to be," he says. "I love my job, I party, I have a good life. There are so many exciting companies to work for now in India that I don't see any reason to leave. I can imagine going abroad for a few weeks on work visits, but I don't see any attraction in living overseas. This is my home." **David Cohen** ●

Bangalore's bars are going trendy to cater for a young crowd

MOBILE MANIA

The number of mobile phone users in India outnumbered fixed-line subscribers for the first time in October last year

● Mobile phones ● Landlines ● Internet



Millions go mobile

A BILLBOARD in Bangalore screams "800 million people". That's how many Indians the mobile phone company Airtel claims to be able to reach. Given that this is nearly 20 times the number of people in the country who actually own a mobile phone, Airtel's claim may seem pointless. But the message is clear enough – India is being connected as never before, and the consequences could be dramatic.

Take Reliance Infocomm, the communications wing of India's largest industrial group, Reliance. Starting in 1999, the company has laid 80,000 kilometres of fibre-optic backbone to connect the base stations making up its wireless network. Its wireless services are already available in 1100 cities and towns, and the company says that more than 5000 towns and 400,000 villages will be covered by the end of 2005. In December 2004, Reliance became the first provider in India to have signed up 10 million subscribers.

Though numbers like these have telephone firms drooling, competition is intense and long-distance calls on some Indian networks cost as little as 4.5 US cents a minute, among the cheapest in the world. As a result, mobile phone ownership in India has rocketed from zero to 45 million in less than four years. Users are joining at the rate of 1.5 to 2 million a month. In October 2004, numbers of cellphones outstripped landlines. By 2008, 200 million are expected to have a cellphone.

Granted, this is still a fraction of India's billion-strong population. But mobile phones are no longer just the domain of the rich and privileged, as their practical benefits have attracted Indians of most economic classes – far more than computers and the internet have. Prakash Sharma, an autorickshaw driver in Delhi, is typical of Indians on a modest income who see owning a mobile phone as a sensible investment. "It's good for business," he says. "Call me and I'll come and get you from anywhere in the city."

With handsets costing \$50 or more, they are still out of reach of the poorest, but that could soon change. In December, handset maker Nokia announced plans to build a manufacturing plant in India. Some observers say this could slash the price of basic handsets, and make them affordable to people on lower incomes. **David Cohen** ●



CHRISTOPHER ANTONSON/REUTERS

Make it pay

R. A. Mashelkar is campaigning for a new way of thinking

 **SPEAK** to people in the know about the state of science in India and the chances are the name R. A. Mashelkar will be mentioned sooner rather than later. Raghunath Anant Mashelkar is director-general of the Council of Scientific and Industrial Research (CSIR), the world's largest network of public-sector research centres. But this urbane and softly spoken scientist is also running a one-man campaign to create an enterprise culture in India: to bring science and industry together to increase the country's wealth and well-being. To western ears his ideas may seem nothing out of the ordinary, but they are provoking a revolution in India.

Walk around any Indian city centre today and you will see four-wheel drive cars and top-end BMWs. The shops are full of the same branded goods that you find in London or New York. But it was not always like this. Until 1991, government policies made it difficult for foreign companies to set up shop in India or even sell their goods there. For most products, Indian consumers had to settle for locally made copies. In this environment, there was no motivation for Indian firms to innovate. "Demand on science from industry was sadly missing," Mashelkar says. "The fact that science has to make economic and social sense had not dawned on large numbers of our institutions."

But through the 1990s, the country opened up to foreign companies and goods – a change that not only prepared the ground for the recent influx of high-tech companies but also exposed Indian firms to intense and unfamiliar competition. To Mashelkar, the response was obvious: companies must learn to innovate and get closer to innovative researchers.

In 1989, he took over the National Chemical Laboratory – one of the CSIR centres. Here, he set up a business development group and a "kite-flying fund" for ideas that had only a 1 in 1000 chance of succeeding. Such notions were unheard of in government labs, but when he took over the CSIR in 1995 he applied them across the whole network. "We set up a new ideas fund. We knew we would be supporting failure, and there was some opposition," he says. "But it sent the idea round the CSIR that you can dream, you can think out of the box. And we saw the impact of that in other areas of work."

In another break with the past, Mashelkar urged scientists to patent their ideas. They had



R. A. Mashelkar came from a poor family. He went barefoot to school in Mumbai until the age of 12, and was able to continue his education only after he won a scholarship. He studied chemical engineering at the University of Bombay, then moved to the University of Salford in the UK. He returned to India six years later as deputy director of the National Chemical Laboratory. A highly regarded polymer chemist, he is a fellow of the Royal Society in London and still runs his own lab.

not done so before because industry wasn't interested. The CSIR itself used to apply for only half a dozen patents a year; now it files for hundreds. And in 1997, when a company was awarded a US patent for the wound-healing powers of turmeric, Mashelkar fought the decision and won, arguing that the patent would "steal" India's traditional knowledge. India has since successfully challenged patents on neem and basmati rice.

Mashelkar's latest baby is the New Millennium Indian Technology Leadership Initiative (NMITLI), which gives government money to projects in which universities, government labs and companies work together to make world-beating products. It has already generated two drugs in clinical trials – for TB and psoriasis – and a software package called Bio-Suite that does everything

from analysing DNA sequences to manipulating virtual molecules in three dimensions. Bio-Suite was created by several institutions, including the Indian Institute of Science in Bangalore and the Institute of Genomics in Delhi, and was launched last June by Tata Consultancy Services. "Tata couldn't have done it on its own, neither could the universities," Mashelkar says.

Mashelkar's influence extends into government circles. One evening he got a call from the finance minister who needed to make a splash in his budget speech. He asked if Mashelkar had anything up his sleeve. The result was the NMITLI. "I've made presentations to five prime ministers," he says. "All have supported science unequivocally." In recent years, the CSIR's budget has grown by more than 25 per cent a year.

Beyond the CSIR, Mashelkar sees the arrival of foreign companies' R&D centres as a godsend. He has long complained that losing even a few talented people has a disproportionate effect on India's intellectual and economic development. Now foreign companies are bringing expats back by the thousand. Many of those returning have been exposed to western innovative culture, and some will transfer to Indian firms or set up on their own. These companies will in turn soon be looking for new blood, producing a "pull" on young people to study science and technology.

It all helps to fulfil Mashelkar's vision of turning India into a nation not only of ideas, but of opportunity too. **Jeremy Webb** ●

"The fact that science had to make economic and social sense had not dawned on large numbers of our institutions"

Vaccines for pennies

They said it couldn't be done

 WHEN Krishna Ella went to venture capitalists in 1995 he was laughed out of their offices.

A molecular biologist at the University of Wisconsin in Madison, he was proposing to make hepatitis B vaccine in India, his native land, for a mere dollar a shot. At the time UK drug firm SmithKline Beecham was selling the product in the west for 20 times that amount. "People thought: there's no way this guy can produce this vaccine at a dollar," Ella recalls.

Undeterred, he and his marketing manager wife Suchitra Ella sold their houses in America and India, abandoned their US careers and left for Hyderabad to set up their own company. They sank all they owned into the venture, begged money from friends, and finally won backing from an Indian bank. Their company, called Bharat Biotech, now sells the vaccine in developing countries for 28 cents a shot. It owns the second biggest production facility for this vaccine in the world and has an annual turnover of \$7.3 million. "Those venture capitalists are kicking themselves now – you bet!" says Suchitra Ella.

The pair are typical of highly educated Indian expats who have forged their careers in the west, but are now returning to take advantage of new economic opportunities at

"Krishna Ella spotted that the method being used to extract the vaccine protein was inefficient and costly"

home. Their intimate knowledge of western science and business is invaluable, and they are natural risk-takers. After all, this is not the first time in their lives they have made a daunting fresh start. "There is always dogma in science," says Krishna Ella. "To break the dogma you need to take risks."

Krishna and Suchitra Ella wanted to give something back to their home country, and setting up in India made good financial sense too. The country's economic liberalisation in the early 1990s has led to a wealth of new business opportunities and there is also a ready supply of well-educated scientists who are less costly than their US counterparts. And some states are throwing money at biotech start-ups. Genome valleys and knowledge parks are the current vogue as politicians try to tempt entrepreneurs with tax breaks, simplified regulation and guaranteed high-quality water, power and communications links.

So how did the Ellas manage to undercut the competition so dramatically? Hepatitis B is caused by a virus that attacks the liver, and which can cause lifelong infection, liver failure and cancer. It is usually spread through sex with someone who is infected, or by drug users sharing needles. In 1986 SmithKline Beecham launched a vaccine for

hepatitis B, the first in the world to be produced by genetic engineering. It is made by adding genetic material to yeast cells so that they produce a key protein from the surface of the virus. People who are immunised with that protein produce antibodies that protect them should they subsequently encounter the virus.

Ten years ago Krishna Ella spotted that the purification method SmithKline Beecham used to extract the vaccine protein was relatively inefficient and costly. The multinational was using – and still uses to this day – a technique called ultracentrifugation, in which samples are subjected to 100,000 times gravity to separate the protein from DNA.

The equipment cost over \$1.5 million and only recovered 15 per cent of the protein. What is more, the technique used caesium chloride, which is expensive and has to be completely removed from the final product because it is toxic. That makes disposal costly too.

Krishna Ella had come up with a new purification process that would eliminate ultracentrifuges and caesium chloride, and boost efficiency to 80 per cent. The vaccine protein has a phospholipid tail that is electrically neutral, unlike most of the yeast proteins and DNA, which carry an electrical charge. With Ella's method, called the Himax technique, the vaccine protein can be made to precipitate out of the solution onto a special matrix, while all the charged molecules stay put.

Bharat has since started manufacturing other products, such as a typhoid vaccine and an antibiotic for use against staphylococcus bacteria, which can cause skin and blood infections and pneumonia.

And the firm has got funding from the Bill and Melinda Gates Foundation to carry out malaria vaccine research and to develop a cheap vaccine for rotavirus, a major cause of childhood diarrhoea in poor countries. This type of diarrhoea kills about half a million children every year.

Krishna Ella says he wants to tackle third-world diseases neglected by the multinationals, a sentiment often voiced by Indian entrepreneurs who believe scientists have a duty to the poor.

"It feels very satisfying," says Suchitra Ella. "We are on top of the world because we are doing something that is really required for countries like India." **James Randerson** ●



Suchitra and Krishna Ella sank their life savings into their biotech venture

Dishes to savour

Why astronomers are flocking to India's wine country

The GMRT's giant antennas extend 14 kilometres from the hub of the array

"I'M IN love with this," says Subramaniam Ananthakrishnan, sweeping his arm over a rural landscape dominated by giant dishes. The radio astronomer has reason to be besotted. He and his colleagues spent 15 years transforming this once desolate region of Khodad, 90 kilometres from Pune in western India, into a home for the Giant Metrewave Radio Telescope (GMRT) – the world's largest, low-frequency radio telescope and India's biggest basic science project.

This is Big Science on anyone's scale. The telescope consists of 30 antennas, each one 45 metres across. Twelve of them sit in a 1-kilometre-square central region, while the remaining 18 stretch out along three arms, each 14 kilometres long. The central cluster allows the telescope to pick up extremely faint signals, and the arms give it high resolution.

The GMRT opens a unique window. Its operating frequencies – between 130 and 1500 megahertz – are at the opposite end of the spectrum from gamma-ray astronomy. "These frequencies have been looked at before, but either the resolution or the sensitivity was not there," says Rajaram Nityananda, director of the National Centre for Radio Astrophysics (NCRA) in Pune. "That combination is unique to the GMRT."

India is a good spot for this world-class facility. The country has a long tradition of radio astronomy and, compared with many rich nations, its airwaves are relatively uncluttered. Through clever innovation, such as using a mesh of fine wires to form the reflecting surface of each dish, Ananthakrishnan and his colleagues, led by NCRA's Govind Swarup, have created a revolutionary, low-cost design. The entire telescope cost \$12 million.

Since the telescope was completed in June 2000, astronomers from around the world have been jostling for time on GMRT. But this happy outcome was not guaranteed, remembers Ananthakrishnan. In 1985, while searching for a site, the astronomers surveyed a region surrounded by lush sugar cane fields in Dhond, about 100 kilometres from Pune. Suddenly, their jeep was surrounded by villagers wielding knives and axes. "They told us that if we tried to purchase their lands via the government, they would quickly dispatch us to heaven," he says. "We saw their point and left Dhond in peace." Later, they settled on Khodad, a once-barren region now fast becoming India's wine-growing centre.



One of the GMRT's main tasks is investigating the clouds of hydrogen gas thought to be the precursors of galaxies. Its biggest asset is its ability to detect a 1420-megahertz radio signal emitted by excited hydrogen gas. In distant galaxies, which are moving swiftly away from us because the universe is expanding, this "spectral line" is shifted to a lower frequency by the Doppler effect. The shifted frequency is well within the telescope's range, allowing astronomers to use it as a probe for studying the dynamics of evolving galaxies.

NCRA astrophysicist Jayaram Chengalur used this technique to look at dwarf irregular galaxies (DIGs) which lack any apparent structure and are thought to give rise to larger galaxies. "Most people believed that very small dwarf galaxies just don't rotate at all," says Chengalur. His team measured the velocity of hydrogen gas in 51 DIGs with great precision (www.arxiv.org/astro-ph/0411664). "We found that very small galaxies do rotate," he says.

GMRT is also valuable for studying pulsars – dense, fast-spinning neutron stars that emit radio pulses at regular intervals. "GMRT can pick

up pulsars that others who traditionally search at higher frequencies cannot pick up very easily," says NCRA astrophysicist Yashwant Gupta. Last year Gupta and his colleagues found a "binary system" comprising a pulsar circling another massive object. It has the most eccentric orbit ever seen (www.arxiv.org/astro-ph/0403453). The researchers' theory is that the pulsar first accumulated matter from a low-mass star, then somehow exchanged that for the more massive one it now orbits. Astronomers believe that a similar process could give rise to a pulsar-black hole binary system. "If you find a pulsar going around a black hole, that will be a fantastic discovery, because you can do all kinds of science with it," says Gupta.

Today, radio astronomers around the world are planning the next-generation radio telescope, which they are calling the Square Kilometre Array. "Everyone is looking at GMRT as a test area for the SKA," says NCRA astrophysicist Pramesh Rao. Radio astronomer Paulo Freire of Cornell University in Ithaca, New York, agrees: "The beauty of GMRT's design is deeply influencing the construction of the SKA." **Anil Ananthaswamy** ●

Voyage of discovery

India's drug companies are risking everything to stay afloat



THE 170-kilometre road trip from Mumbai to Pune presents a rich slice of Indian life. The traffic-choked route out of Mumbai passes through mile after mile of slums where people's lives spill out onto the street – they shower, cook and eat within a metre of the car window. The jams ease through the sister city of New Mumbai, a modern metropolis of skyscrapers, parks and shopping centres. Then we drive onto an Indian rarity, a six-lane motorway, running all the way to Pune. But there is still no doubting where I am: "No bullock carts," proclaims a sign by the roadside.

The reason for my journey is to visit the research headquarters of pharmaceutical company Lupin, set amid fields and hills outside Pune. India's drugs industry is undergoing a revolution. For decades it has flourished under the country's unusual patent laws, under which patents can be taken out on the processes needed to make medicines, but not on the drugs themselves. So the industry prospered by inventing new methods of manufacturing the west's blockbuster drugs, and churning out cheap "generic" versions for sale in India and other developing countries.

In the process, India has developed world-beating expertise in chemistry and spawned an estimated 9000 drug firms. The country is also the world's top supplier of "legitimate" generic drugs – copies of

medicines whose patents have expired.

But on 1 January 2005 internationally recognised patent rules came into force that mean the industry must phase out production of generics that are still under patent. Firms such as Lupin are responding to this loss of income by reinventing themselves as global drug-discovery companies. In other words they are emulating the very same western companies on which they once fed.

At Lupin's HQ, a sprawling research park set amid well-tended gardens, Nilesh Gupta, the firm's executive vice-president, takes me through Lupin's future strategy. The company has chosen to focus on three diseases: TB, psoriasis and migraine (see "Seeds of success", page 46). Gupta is on a high, having recently got the go-ahead to begin trials on the firm's TB and psoriasis drugs. "That's a pretty huge achievement," he says.

Other companies have different priorities. Mumbai-based Glenmark is concentrating on diabetes, obesity and lung diseases such as asthma – illnesses that require long-term medication, and are growing problems in India as well as the west. "They are profitable areas to move into," says Swaroop Kumar, the firm's

Indian-made drugs
have led the fight
against AIDS in Africa



SHERWIN GASTON/PHOTO

A matter of life and death

WESTERN drug companies have developed the medicines that have transformed HIV infection from a death sentence to a chronic but treatable condition. But it is Indian pharmaceutical firms that have led the fight against AIDS in Africa.

Thanks to India's patent laws, which have allowed its firms to produce cheap "generic" versions of HIV drugs that are still under patent in the industrialised world, the cost of life-saving therapy has been slashed from \$10,000 a year to less than \$200. While that sum is still beyond the reach of most Africans, it vastly expands the number of people who can be treated using international aid money.

Fortunately existing HIV medicines will not be greatly hit by India's recent adoption of global intellectual property laws as the new rules only apply to products patented since 1995. And that excludes most HIV drugs.

Nevertheless, US drug firms are using all available means to stop aid money being spent on what they claim are pirated drugs. Last year they successfully lobbied the World Health Organization to impose extra safety checks on generics. The US government also refuses to spend its aid money on drugs that have not been approved by the American drug regulatory agency, the Food and Drug Administration. So far only one generic HIV drug from outside the US – made by a South African firm – has met this requirement.

Two Indian companies have recently had to withdraw products from the WHO's "approved" list because they lacked the necessary paperwork. One company, Cipla, carried out new studies that met the WHO's requirements and got the drugs relisted last November. The other, Ranbaxy, aims to resubmit new data for most of its drugs by March. Several aid agencies have continued buying the delisted drugs, however, because they simply cannot afford the costlier brand-name versions.

With the WHO redoubling its efforts to channel more aid money into HIV treatment, the battle may not yet be over. The organisation has set a target of getting 3 million people in the developing world on anti-HIV medicines by the end of this year. "WHO has the companies in the US looking over its shoulder for weaknesses," says Daniel Berman of Médecins sans Frontières.

India is the world's
biggest supplier
of generic drugs



senior vice-president of biological research. Wockhardt, also based in Mumbai, has set its sights on infectious diseases. Bacterial drug resistance is soaring, points out Mahesh Patel, the company's director of infectious diseases research, yet western firms are moving out of the field and there are few new drugs in development. "The international pipeline is running low," he says. Another advantage of targeting this area is that unlike drugs to treat chronic conditions such as asthma, antibiotics are usually taken only for short periods, so their clinical trials take less time to carry out.

Not all Indian firms are so narrowly focused, however. Nicholas Piramal has recently built a new \$20 million R&D centre in Mumbai to carry out basic research in a wide range of disorders, including cancer, diabetes, inflammation and infectious diseases.

The primary goal of all these companies is to replicate what western firms have been doing for decades, but faster and cheaper. Nicholas Piramal recently claimed that it would bring a medicine to market on a budget of \$50 million. To put that in perspective, western firms reckon the bill for launching a new drug is not far off \$1 billion. How can Nicholas Piramal hope to meet such an ambitious target? As a place to do research, India does have certain advantages. Most notably labour costs are much lower. "A freshly minted PhD in India costs \$10,000 a year, as opposed to \$50,000 to \$60,000 a year in the US," says Ajit Dangi, director-general of the Organisation of Pharmaceutical Producers of India.

Knowledge of how western companies and markets operate is also valued, and many firms are recruiting Indian-born scientists who have spent time in the US or Europe. Although their salaries generally drop on coming home, they end up comparatively better off because of the lower cost of living in India. One such returnee is Nicholas Piramal's new chief scientific officer, Somesh Sharma, who spent the past 35 years in the US where he founded several successful biotech firms. Sharma says that when he arrived back in India one of the biggest culture shocks was people's observance of hierarchy. He recalls the surprise of "everybody standing up as soon as I walk into the room, everybody saying 'sir' and 'doctor'."

Indian drug companies also find it easier to recruit people for clinical trials. For example, when Sharma last ran a study in Europe of a potential new diabetes drug it took a year to ►

"The biggest challenge for the embryonic drug discovery industry is the risky nature of pharmaceutical research"

find 100 patients. Recruiting that number in India took him only 30 days. It is not just that India has a vast population but also drug companies are not competing so fiercely for patients as they are in the west. In addition, Indians are less likely to be taking other medicines that could interact with the test compound. "It's easier to look at a new drug on a treatment-naïve patient rather than on someone who has taken every drug under the sun," Sharma says. But that does not mean companies target poorer people for their trials. They make less than ideal experimental subjects, he says, because they may be undernourished and are less likely to turn up for all their hospital appointments.

It's for reasons like these that many western firms, such as AstraZeneca, have opened large research centres in India or set up major collaborations with local firms – the Danish-based multinational Novo Nordisk with the Indian Dr Reddy's, for example.

Although India has its advantages, it also presents some unique challenges. Roads and water supply are often poor and in many places power cuts are common. Within the industry itself there is acceptance that corruption and excessive bureaucracy are part of the system. Then there is the lethargic approach to getting things done. Sharma says that if he needed to order a reagent in the US he could call at six in the evening and receive it next morning. "In India, it can take three weeks," he says. "There is a lot of inertia."

Another stumbling block is that a strong animal-rights movement, together with complex and confusing laws, have virtually stopped research on large animals such as dogs and primates. Most firms now outsource large-animal work to Europe or the US.

But perhaps the biggest challenge for the embryonic drug discovery industry is the intrinsically risky nature of pharmaceutical R&D. Western drug firms have found to their cost that only 1 in 10 compounds that make it

to clinical trials ever reach the market.

One company aware of this pitfall is Dr Reddy's, based in Hyderabad. Development on two of its lead compounds for diabetes has recently been suspended. It transpired that one, called balaglitazone, had little benefit over medicines already available. The other, called ragaglitazar, was the first in its class, and human trials showed it benefited both patients' blood sugar and cholesterol levels. But studies revealed that it caused cancers in rodents.

Undaunted, company founder Anji Reddy, points out that his was the first Indian firm to set up its own R&D programme more than a decade ago. "In 1993 when I was the president of the Indian Pharmaceutical Congress I said very clearly that companies have to get into drug discovery. And why not?

We have the talent pool." Dr Reddy's has eight new compounds ready for clinical trials, he says, and is on course to produce another three a year for the next three years. So, according to the 1-in-10 statistic, at least one, and perhaps two of those compounds could hit the jackpot.

India's fledgling drug discovery industry will undoubtedly produce both winners and losers, but at the moment all bets are off. The next few years are likely to see a spate of mergers and take-overs that could restructure the 9000 existing companies into as few as 500.

One thing is certain: for drug companies in India, standing still is not an option. "Unless they change their business model from imitation to innovation they will not survive," says Dangi. "The free lunch is now over." **Clare Wilson** ●



Aloe vera is a traditional ayurvedic medicine

Seeds of success

HERBAL therapies are a big part of India's traditional ayurvedic system of medicine. While most of them have not been tested scientifically, some Indian firms are using them as a starting point for drug discovery.

Nicholas Piramal, for example, owns a library of 5000 botanical samples together with information from ayurvedic texts on which illnesses they are used to treat. Plant extracts are tested for activity against numerous different cell and tissue types, starting with those that seem most relevant to their traditional use. "If you look at ayurvedic text, you can get wonderful leads from that," says H.S. Parikh, the company's vice-president of clinical research.

When a useful plant chemical is found, its molecular structure can be tweaked to improve its effectiveness, for example by making it bind more

tightly to the target molecule in human cells. This step has another important advantage. "You need to modify it so you can patent it," Parikh says.

Lupin also has a rich plant library. The firm is developing a herbal psoriasis medicine for the Indian market. But it has also isolated the plant's active ingredient, which it calls desoside-P, and is developing that for the international market. The compound seems to work by raising levels of interleukin-10 in the skin – this biological signalling chemical is known to alleviate psoriasis flare-ups.

Desoside-P could also have potential against other autoimmune diseases, perhaps including rheumatoid arthritis, says Nilesh Gupta, the firm's executive vice-president. "If it works in one," he says, "the chances are it should be tested in others."

We have to take risks

After earning his master's degree at Delhi University, **Shobo Bhattacharya** left India to spend 30 years working as a physicist in leading US labs, including MIT, Argonne National Laboratory and the University of Chicago. Two years ago, he returned to one of India's top science jobs, director of the Tata Institute for Fundamental Research in Mumbai. TIFR is a national institution in every sense. It was created in 1945 by three of the India's founders and is now the country's premier research centre for physics and maths. He talked to **Jeremy Webb**



Bhattacharya was the first director of the TIFR never to have worked in India

This led the scientific community to develop a sort of disdain for things that are technological. As a result, the best and the brightest saw science as an end in itself: essentially an intellectual pursuit without any regard to what it can give back to society.

What about the state of Indian science, is it healthy?

No it is not. That's my personal view. I think what has been devastating to Indian science is the weakening of the university system in terms of science, research and teaching put together. And unless that is corrected I don't think Indian science will ever be healthy.

You cannot build a robust scientific infrastructure on stilts – isolated centres like ours. It has to have a base, and that is the university system, where a large number of students get a high-quality education. If they go for a master's degree or whatever, it should happen in an environment where research is done, where there's a sense of vitality.

What do you want to achieve as director of TIFR?

TIFR needs to reorientate itself. This is quite controversial. One difficulty of our society is that we are often not willing to rethink things for ourselves, particularly in institutions that were built by giants. There is a tendency to say that the giants have done all the thinking for us for all time. If I achieve one thing it will be to get people habituated to the idea that we must re-examine ourselves routinely.

I'll give you an example. Physics was a very important thing in the 20th century. In the 21st century it is a very mature subject. Should TIFR have the same composition in the various sciences today as it did 50 years ago? I strongly doubt it. If we don't rethink we are not going to change and science will leave us behind.

It's about taking risks?

It is about taking risks by rethinking the kind of science we do. I'll quote you something attributed to Wolfgang Pauli. He said there are three kinds of science: the best is where the results are right. Then there are the results that are wrong. Then there are the results that are not even wrong. We cannot afford to do the third kind of research. ●

Are there big contrasts between US and Indian science?

Societal context makes a great difference. Take physics, for example. Most of our students wish to do theoretical physics. If you ask them why, they have no real reason, it is just that society places a higher value on things driven solely by the brain. This is in dramatic contrast with the US, which is a society that adores building things. There, many brilliant scientists are also adept with their hands. Another contrast is that the relationship between science and technology – the idea that science leads to technology, leads to commercial activity, leads to the generation of wealth for the nation – is very poorly understood here.

In space and nuclear science, Indian researchers take great pride in doing science "for the country". Does that extend to TIFR?

I think this is a kind of Gandhian ethos of self-reliance. It is still present, but it is not as apparent here at TIFR as it is in places like nuclear research centres.

But science is not national, it's global. Do you think India is losing out with this attitude?

I consider this one of the central dilemmas of science in India. There has been a strong historical emphasis on self-reliance and indigenisation. In my childhood, something

built in India was a source of great pride. Whether it was built well or not was a secondary question. And this idea still lingers on in places. But not so much at TIFR.

I like to say, tongue in cheek, that there is no such thing as a "Bombay electron". An electron does in Bombay (Mumbai) pretty much what it does in Boston. An electron discovered once is discovered for good. In science you cannot be second, because the first person at the frontier is the frontier. TIFR wants to be at the frontier.

Do you push your inventions out to industry?

We try to. I have a colleague who has a new optical technique that has great potential. But in India there is no capacity to exploit it. So we are in negotiation with European companies Zeiss and Leica to see if they are interested.

Why is industry absent, then?

If you go back to 1930, when C. V. Raman won India's Nobel prize for physics, Indian industry was not capable of even making paper clips. It was very backward. So when the country became independent we had a few isolated but significant scientific accomplishments set against a backdrop of essentially no industrial capacity. This is very unusual if you think of the European and western context where science and technology progressed together.

Daring to be different

India has bold plans for a nuclear future

IN THE 8th century, the Pallava kings who ruled southern India made Mamallapuram their main port on the Bay of Bengal. They had caves and temples carved from the granite hills behind the town, which is still a centre of pilgrimage. These structures are also inspiration for scientists working at the Indira Gandhi Centre for Atomic Research, whose stacks are visible from Mamallapuram. "If our ancestors could build temples that last 13 centuries, it should not be beyond us to build a reactor that lasts 60 years," says Baldev Raj, director of the IGCAR.

Raj's temple of the future, which is now being built, is a 500-megawatt, sodium-cooled, fast breeder reactor, which generates not only electricity but plutonium too. Many countries – the US, UK, France and Japan among them – have toyed with commercial-scale fast breeders, but their programmes have either crashed or been halted. Only Russia has run a large fast breeder for any length of time. Yet India is determined to follow this apparently risky route as a key step towards long-term self-sufficiency in energy.

The average Indian is electricity poor, consuming just 600 kilowatt-hours a year, enough to keep a fridge running. By comparison, average consumption in wealthy OECD nations is 10,000 kilowatt-hours a year. Yet even if every Indian used just half that amount, by 2050 the country would need 10 times as much generating capacity as it has now. One way to fill that gap is to use coal, but

though India has plenty of it, the coal is mostly of poor quality, so burning it would push up pollution and global warming.

Oil and gas are in short supply, so India is looking elsewhere. It has small stocks of uranium and about a quarter of the world's supply of thorium, which is rarely used in reactors because it is not fissile – that is, its nucleus does not readily "split" to release energy. Yet India's nuclear vision is to use these reserves to keep its power lines humming for centuries.

The IGCAR is one of the nerve centres of this programme. Built on the sandy coastline beside the fishing village of Kalpakkam in Tamil Nadu, it has the feel of a university campus. Some 1200 scientists work in white, stately buildings and strange-shaped industrial units surrounded by casuarina trees.

Here is everything you would expect to see in a nuclear research centre. A huge team of materials scientists study creep, fatigue and corrosion, and create new materials. There is a particle accelerator that bombards materials with protons to simulate neutron damage, and labs devoted to studying sodium and giant robots. Elsewhere engineers bend huge metal components to make sure they outperform their safety specifications and test model structures in earthquake simulations.

The vision these people are pursuing comes in three stages, each using a different type of reactor. The first stage is well under way: India has 12 water-moderated reactors burning natural uranium. Neutrons flying around in

"If our ancestors can build temples that last 13 centuries, it should not be beyond us to build a reactor that lasts 60 years"

these reactors not only induce uranium-235 to split and release energy, but also convert non-fissile uranium-238 into fissile plutonium-239 (see Diagram).

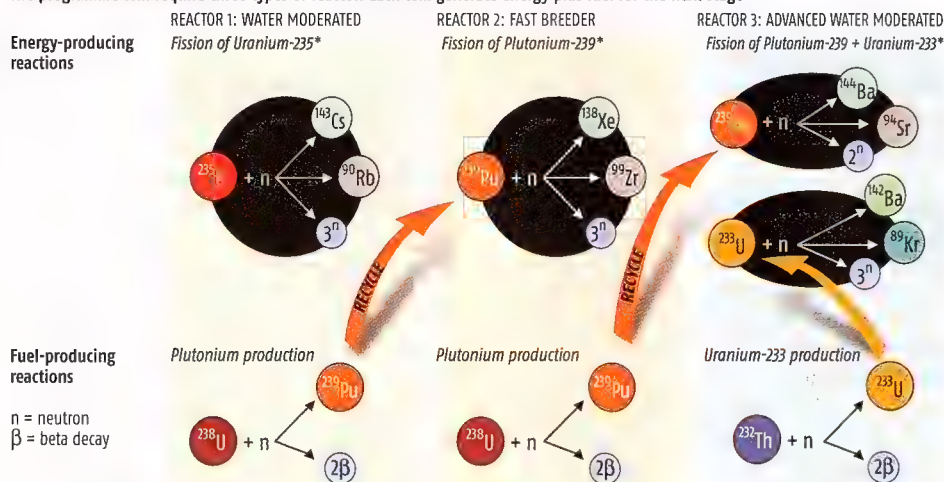
This plutonium will be recycled for use in the second stage – the Kalpakkam fast breeder – which will work in a different way from the existing power reactors. In water-moderated reactors, water slows neutrons down. But fast reactors like their neutrons "fast", or energetic, so the water coolant is replaced with liquid sodium, which does not slow down the neutrons. One of the controversial quirks of these reactors is that by surrounding the core with a "blanket" of uranium-238, it is possible to create more plutonium than is used as fuel.

The final stage is to reclaim this plutonium and use it in an advanced water-moderated reactor, which is still at the design stage. The plutonium would be added to uranium-233, another fissile form of uranium, and thorium-232, which is transformed into more uranium-233. This is later separated from the spent fuel and recycled. By repeated recycling India should squeeze out far more energy from its uranium than if it had just been burnt once. The supplies should last for more than two centuries, says Raj.

This is a colossal endeavour, but India should have the resources to carry it out. While the nuclear industry has been fighting for its life in the US and Europe, in India it has thrived. This has happened largely out of necessity. India has been shunned by other nuclear countries since 1974 when it exploded its first

INDIA'S NUCLEAR VISION

The programme will require three types of reactor. Each will generate energy plus fuel for the next stage





nuclear bomb. Since then, it has updated and built its own reactors, starting from an old Canadian water-moderated design. As well as the 12 in operation, another six are being built.

India is self-reliant in other areas too. It cannot buy uranium from abroad or import nuclear technology so it has developed expertise in fuel processing and reprocessing. Kalpakkam is home to two experimental reactors – a small fast breeder and a reactor called KAMINI, which is the world's only working plant fuelled by uranium-233. The relatively small fuel loads for both plants are produced in India.

More reactors, more radioactive waste – in Europe and the US campaign groups would be marching in the streets. But in India there seems to be no national voice against civil nuclear power. Protest focuses mainly on safety issues around individual plants and uranium mines. Still, some critics ask why India is going nuclear at all when it has plenty of potential sites for miniature hydroelectric plants, wind and solar power. "Reactors are basically meeting the needs of cities," replies Raj. "But whether a big grid is suitable for rural areas, I think the natural answer is no." He sees small-scale plants and renewables as a priority

Kalpakkam is already home to a small, experimental fast breeder reactor

for improving quality of life in rural areas.

His view is echoed even by organisations that promote sustainable development, such as the New Delhi-based non-governmental research organisation The Energy and Resources Institute (TERI). India's electricity needs are such that "it makes sense to move in the nuclear direction", says Pradeep Dadhich, an energy expert at TERI. But the government has also identified 80,000 villages that are unlikely ever to be connected to the grid, so India's power sources must always be mixed, he says.

For all that, opting for fast breeders is a bold move. The first commercial fast reactor, called Fermi 1, was built at Lagoona Beach, near Detroit in the US. It closed after only three years when a blocked sodium cooling circuit caused the core to overheat and melt. The US abandoned the technology for good in the mid-1990s when uranium prices fell and the government decided that having reprocessing plants round the world turning out plutonium was a bad idea.

In 1986, France switched on the biggest-ever fast breeder, the 1200-megawatt

Last year's tsunami left the fast breeder's foundations under 7 metres of seawater



Superphenix, but that was plagued by sodium leaks and was closed down 12 years later in what the nuclear industry insists was a “political decision”. Monju, a Japanese fast reactor, suffered a sodium leak and fire in 1995 – a year after starting up. Plant managers tried to hush up, and the reactor has been closed down ever since.

Raj is aware of all this. “We have studied the strengths and weaknesses of all the international designs,” he says. “Our reactor incorporates the best design features internationally.” Pipes carrying sodium, for example, will be surrounded by inert nitrogen to reduce the risk of sodium fires, and the team has devised sensitive detectors to pick up sodium leaks within seconds.

Nevertheless, bad luck has already hit the reactor from an unexpected direction. The tsunami that swept across the Indian Ocean in December tragically killed five people at IGCAR. The reactor’s foundation – a 100-metre square raft of concrete – was submerged under 7 metres of mud and water. It now looks as though a second raft will have to be built on top of this contaminated structure before the reactor can be built. Discussions are under way on whether the site needs better sea defences.

Despite the unfortunate record of fast breeders up to now, international opinion

“Despite the unfortunate record of fast breeders up to now, international opinion seems to be swinging back towards them”

seems to be swinging back towards them. Governments of 10 countries, including the US, UK, France, Canada and Japan, have identified these reactors as candidates for making nuclear power more “sustainable”. Fast breeders can be configured to burn up radioactive isotopes, which could reduce amounts of long-lived radioactive waste. They can also be run at temperatures high enough to “crack” water and produce hydrogen – to supply the coming hydrogen economy. If these attitudes prevail and India’s programme succeeds, the country could find itself not so much a nuclear pariah as an atomic guru. **Jeremy Webb** ●

Sight for sore eyes

An Indian hospital is pioneering a stem-cell cure for blindness



 PICTURE the scene: a distraught parent rushes to hospital clutching a screaming toddler.

While the mother’s back was turned, the child had picked up a household cleaning product and managed to squirt some in her eye. Doctors find that the cornea, the clear surface layer over the centre of the eye, has been severely damaged.

Living almost anywhere else in the world the girl would be likely to end up permanently blind in that eye. But this child is lucky. She has been taken to L. V. Prasad Eye Institute (LVPEI) in Hyderabad, a charity hospital carrying out pioneering medical research. Here she will receive innovative stem-cell-based therapy that has a good chance of restoring her sight.

Despite predictions that by the 21st century bioengineered replacements for damaged body parts would be readily available, at the moment this is only done routinely with two tissue types. Burns patients can be grafted with sheets of living skin, grown from the foreskins of circumcised babies. And people with knee cartilage damage can have some of their own cartilage cells removed, grown in the lab and reimplanted into the joint. Corneas are next on the list.

Chemical injuries to the eye are not uncommon in India. People often buy cleaning products in individual sachets, and when they are opened, fluid can squirt out in unexpected directions. If the surface of the eye is damaged this way, or by injury or disease, one option is a

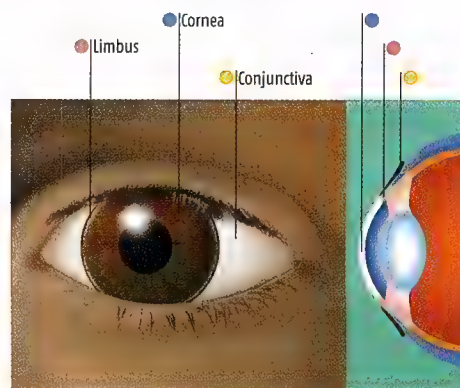
Until now, transplant has been the only treatment for serious cornea damage

cornea transplant from someone who has recently died. The LVPEI has a team of counsellors based at nearby hospitals to encourage bereaved relatives to give permission for cornea donation. This strategy means the institute is now carrying out more than 1000 corneal grafts a year.

But a transplant is not an option if the damage to the eye is too extensive. The cornea comprises a surface epithelium five or six cells deep, above a thick, transparent layer called

A CURE FOR BLINDNESS

The limbus, a narrow ring of cells around the cornea, is a source of stem cells that can repair the cornea itself



the stroma and a third cell layer, the endothelium, at the base. The cells of the surface epithelium are constantly replenished throughout life by new cells arising from the limbus – a narrow ring of stem cells surrounding the cornea – that migrate inwards (see diagram). If the eye damage extends to the limbus, then a cornea transplant will not be successful, as there is no source of new epithelial cells.

But over the past decade several research groups including those at LVPEI have developed a technique to help patients with limbal damage. If a patient has only had injury to one eye, the team can take a small number of limbal cells from the other without harming it. Alternatively, a relative may be willing to donate some from one of their eyes, although the patient then has to take immunosuppressive drugs to prevent the cells being rejected.

The cells are cultured on a sheet of human

amniotic membrane – obtained during Caesarean section operations. The few cells the membrane contains are destroyed so that they do not provoke an immune response in the recipient. After two weeks the epithelial cells are ready to be transplanted, membrane and all, onto the patient's eye. First the transplant region is cleared of cells that have grown over the wound. "It is like gardening," says LVPEI researcher Geeta Vemuganti, "You take away the waste first."

Since adopting this technique four years ago, researchers at LVPEI have introduced several refinements. For example, stem cells used to be cultured using calf serum and mouse cells, but the team developed a way of incubating stem cells in the patients' own blood serum thus eliminating a potential source of infection.

Now they are carrying out more procedures than any other hospital. About 250 patients have been treated at LVPEI, with a success rate of about 70 per cent. For those who can afford to pay, the treatment costs between \$140 and \$230. But LVPEI's charitable foundation means that it can treat many poor patients free of charge. Last year, its doctors carried out 22,951 eye operations, 9992 of which were free.

The team has also pioneered a way to treat patients whose eye damage extends beyond

the cornea and limbus to the surrounding conjunctiva. They discovered that, unlike the cornea, the conjunctiva has stem cells scattered throughout, so small slices can be grown in the lab and expanded.

The team hit a problem, though, when they tried to culture a combined graft – the corneal and conjunctival cells merged to form a mish-mash of both types. To get around this the researchers placed the limbal stem cells inside a perspex ring with the conjunctival stem cells outside (*Bioscience Reports*, vol 23, p 169). They have now treated around 40 patients with tissue grown in this way, with a success rate of about 50 per cent. "Nothing else can be offered to these patients," says Vemuganti.

Although LVPEI's researchers did not invent limbal stem cell grafting, they have made significant technical advances in applying the therapy. What was a highly experimental treatment is slowly becoming routine. "We are not the pioneers," says D. Balasubramanian, LVPEI's director of research, "But we can certainly claim widespread application." **James Randerson** ●

Nearly half the operations at the L. V. Prasad Eye Institute are free of charge



www.newscientist.com/channel/health

Reinventing India

In 1981, **Nandan Nilekani** was one of seven engineers in Pune who scraped together \$250 to start a software company called Infosys. In a radical move for an Indian company they looked overseas for inspiration, sending employees to develop low-cost software in the US. In April 2004 Infosys became India's first publicly listed IT company to exceed annual sales of \$1 billion.

Anil Ananthaswamy asked Nilekani, who is now CEO of Infosys, how it happened and what it means for the future of India



What was world's perception of Indian programmers when you started?

There was no perception. It was an uphill struggle to convince foreign clients that we could do what they wanted.

How did you do that?

At the heart of our pitch were India's strengths as a nation. The widespread use of English, the large technically trained workforce and what seems to be an innate talent for computer programming all helped. For Infosys the social changes that were sweeping India, such as a new-found drive for entrepreneurship and the liberalisation of domestic markets, also provided a shot in the arm.

What makes Indian software development stand out?

The Indian way of working. This means breaking down big software projects into chunks that can be tackled simultaneously by many groups worldwide, and then drawing them back together to create a single product. We needed new management processes and new software tools – Infosys pioneered this way of working.

How has Infosys helped change India's image overseas?

We have gone from an era when it would have been inconceivable for Indian companies to

compete with western companies, to a time when we are fast becoming one of the most important technology development centres in the world, all in the space of two decades.

Many western companies have opened operations in India. Has this changed the sort of work done here?

Yes. Large western companies, such as Texas Instruments and Intel, are doing very sophisticated work in India – they are building the next-generation chips. Many venture capitalists in Silicon Valley now insist that development be done in this country. That means a significant section of the next generation of technology companies will have research facilities here.

What will the consequences of this change be?

We are creating an alternative innovation centre to those in the west because there is intellectual muscle, money and a growing domestic market here. That should help stem the brain drain to the west.

There will also be an impact on students overseas. For example, US students will worry that IT jobs will migrate to India and so will stop studying technical subjects. They are already becoming wary of going into a field which will be "Bangalored" tomorrow.

If the immigration of technology experts to

Nandan Nilekani heads the first Indian IT company with \$1 billion sales

the US and the supply of their graduates eventually dry up, then I can imagine the centre of gravity of innovation drifting east.

What could derail this process?

Indian infrastructure. For example, outside our campus, Bangalore is straining to keep up with the pace of change the IT industry is forcing on it. The environment has not developed the ability to respond to the change.

India's problems are diverse and daunting. How can IT help?

None of us claim that the IT industry is a panacea for India's problems, it would be ludicrous to say so. But what we have done is significant. It is a necessary condition for progress, because our actions have had an impact globally and have shown the power of human capital in India. The growth of the industry has shown us what can be: it has shown us the change that we need in this society. We need to use the momentum to change other parts of our society. That's the leap in leadership which is missing. ●

Welcome to the global village

The internet has arrived in Pinjavakkam

 SEGAYA SHALINI is an unlikely internet entrepreneur. She lives in Pinjavakkam, a village of about 500 people 100 kilometres west of Chennai in Tamil Nadu. Pinjavakkam has an intermittent electricity supply and only five telephone lines, yet Shalini has organised an "always-on" internet connection to let locals surf the web as they would in any other internet cafe.

With her webcam and microphone, Shalini offers her customers email access, virtual consultations with a doctor, a weekly Q&A hour with farming experts in Chennai and even the chance for people who won't or can't use a keyboard to catch up with distant friends and relatives. Shalini's business has been made possible thanks to Ashok Jhunjunwala of the Indian Institute of Technology in Chennai, who is creating cheap technologies that will extend the modern world to the most remote places. Pinjavakkam is one of 193 places in the area that are part of his most successful project so far.

Jhunjunwala has connected these sites to the internet via a system he developed called corDECT, which exploits essentially the same digital technology that connects a domestic cordless phone to its base station. Only in this case Shalini's computer replaces the handset, while the base station is an antenna 10 kilometres away. Because of its higher data rate corDECT has the edge over mobile phone networks, which also reach several of his networked villages. Mobiles phones manage 9.6 kilobits per second at best, while corDECT operates at up to 70 kilobits per second.

Jhunjunwala's idea has enjoyed explosive success. The first trial system was installed in February 2000. Today, some 50,000 villages across India are hooked up, and more than a million people bought into the system last year alone. Telecoms companies in South Africa, Tunisia, Kenya, Kazakhstan, Fiji and Yemen have also adopted the system.

But what do people in rural communities, many of whom are struggling to make ends meet, need the internet for? Shalini, who set up her business with a micro loan, is still struggling to answer that question, and is having a tough time convincing some local people to give it a try. "Not many people come

here, maybe five or six customers a day," she says. "Most are students checking their email."

Jhunjunwala's thinking is different. He has a "build it and they will come" attitude. "There are a lot of rural uses," he says. Businesses just have to find the ones that appeal to rural people. "Few businesses will come to rural areas because one village will only produce a few dollars a month in revenue, but if they have access to tens of thousands of villages, the business model starts to add up."

One service that has been a resounding success is e-choupal – *choupal* means meeting place in Hindi. It is a system created by a Kolkata-based trading firm called ITC to provide farmers with real-time prices for their crops so they don't get ripped off by middlemen. Farmers can also buy grain, farming tools and get weather reports online in their own language. More than 3 million farmers in northern and central India now use the system. ITC is installing satellite internet connections at select rural centres and receives a fee for every purchase made through the site.

Jhunjunwala has moved on to develop other low-cost technologies. He is creating interfaces that will allow blood-pressure gauges, pulse meters and ECG recorders to connect to a computer so that doctors can diagnose patients' illnesses remotely. For people who cannot afford PCs, his group is

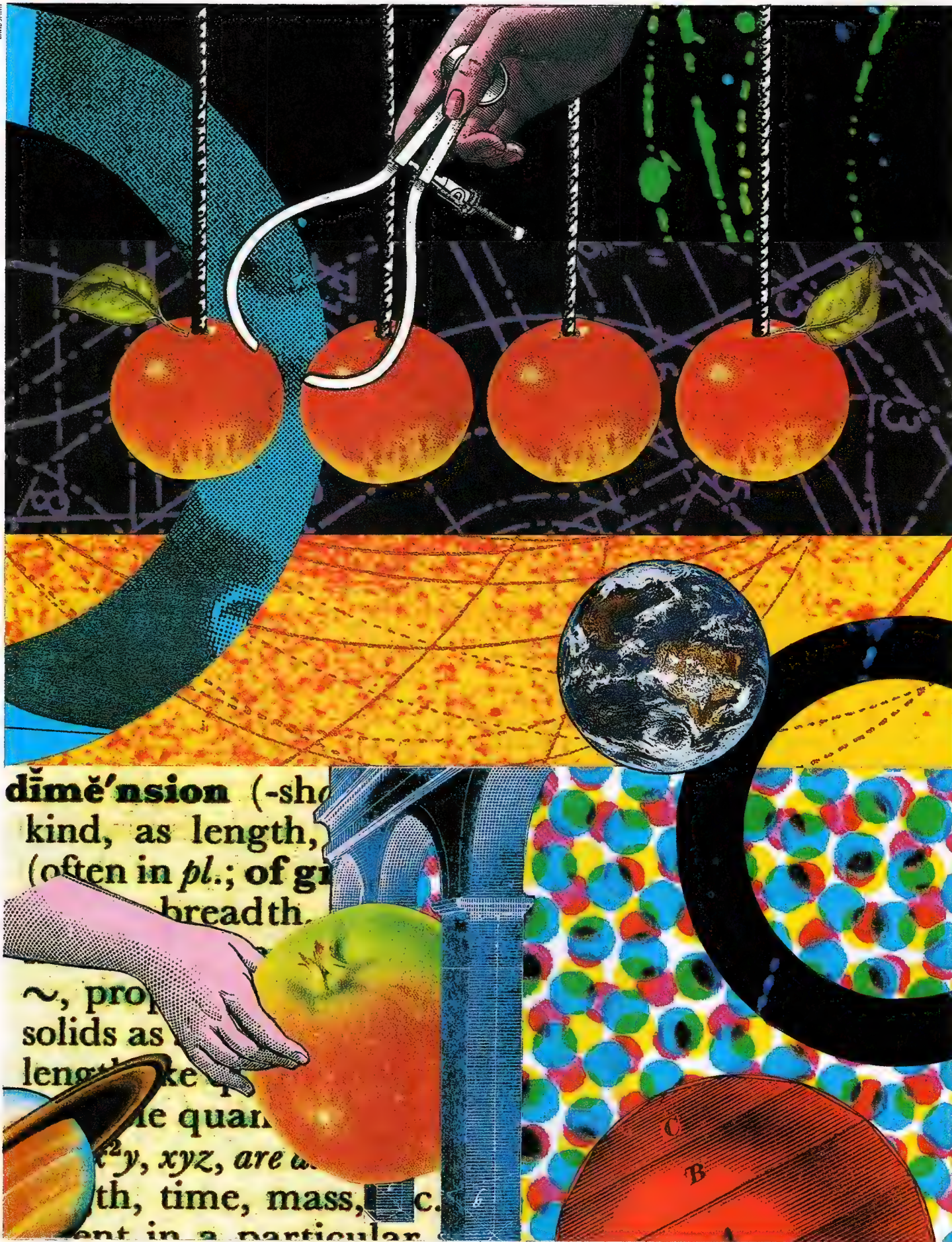
"One village only produces a few dollars in revenue. But give businesses access to tens of thousands of villages and the dollars start to add up"

developing a "thin client" – a cut-down computer that runs programs off a central server, which supports many users and can be based kilometres away. He expects the units to cost around \$130 each.

"Our income in India is a fraction of your incomes in the US and Europe," says Jhunjunwala. "So we need high-tech solutions that cost a fraction of their price in your countries." Otherwise, millions of people will continue to go without. **David Cohen** ●

Can farmers afford not to use the internet?







TO SOME, it might seem that Eric Adelberger is on a wild goose chase. Not only is he trying to disprove Newton's law of gravity, which has withstood over 300 years of scrutiny, but for years now every experiment he has done at the University of Washington in Seattle has come up with zilch.

Despite this, Adelberger has no shortage of graduate students keen to help, even though they are all getting null results too. So what's going on – why do they bother? Because the first person to find what they are looking for will make history. Find the blip, and you have proved that gravity leaks out from our world into hidden dimensions.

It might seem like a far-fetched scenario, but it seems to be the best way to explain the strangeness of gravity, a force totally unlike the three others we have observed in the universe – the electromagnetic, strong and weak forces. For a start, every bit of matter, from the tiniest speck of dust to the greatest star, generates gravity and attracts every other thing. But its most curious aspect is its strength.

Gravity is vastly weaker than the other three forces. You only have to look at a fridge magnet to see that: even for a fairly heavy magnet, gravity's pull – which is also proportional to the enormous mass of the Earth – is as nothing compared with the attraction to the fridge door. Nobody has yet managed to explain the huge gulf in strength between gravity and the other forces.

Adelberger's search for an explanation

began in 1998. That's when Nima Arkani-Hamed, now at Harvard University, Savas Dimopoulos from Stanford University in California and Gia Dvali of New York University came up with a hypothesis. The three theorists had been playing with the idea of extra dimensions, because modern theories that unite gravity and the other forces of nature often require that the universe has extra spatial dimensions too tiny for most experiments to observe (*New Scientist*, 29 September 2001, page 26).

Arkani-Hamed and his colleagues did some reading and uncovered something intriguing about these extra dimensions. "They dilute any force that goes there," Arkani-Hamed says. "There's just a lot more room to spread out, so the forces appear to be weaker." They realised that this might be the answer to the physicists' puzzlement. But how to find out for sure?

One of the predictions of the theory is that leakage into those extra dimensions might cause gravity to deviate from Newton's inverse square law. This law of gravitational attraction says that the mutual pull of two objects decreases in proportion to the inverse of the square of their separation. That's because the way gravity varies with distance depends on the number of dimensions the space has.

In three dimensions, the surface area of a sphere surrounding a point mass increases as the square of the radius of the sphere. The idea is that, since the total "amount" of gravity reaching successively larger spheres should remain constant, the strength of that gravity

therefore falls off like the inverse of the square of the distance. In four dimensions the surface area of a sphere depends on the cube of the radius, in five it's the fourth power, and so on. So in higher-dimensional spaces, the force of gravity must dissipate ever more rapidly, which means it will no longer obey Newton's inverse square law, but some law in which its strength falls off far more sharply.

Strange attractor

It was a tantalising idea: if our universe has hidden dimensions, then at distances smaller than the size of the dimensions, particles might be attracted to each other in a way that breaks the inverse square law. The only problem is that most physicists think these extra dimensions could be very small indeed, and they believe the size that would make most sense is the so-called Planck length. This is a unit of length arrived at by combining quantum-mechanical and gravitational constants, and is roughly 10^{-35} metres – about a hundred-millionth of a trillionth of the size of a proton. However, although many physicists feel the Planck length is the natural scale for the bundled extra dimensions – and no experiment has ever ruled this out – it is still only an assumption. And it is one that Arkani-Hamed and his colleagues quickly undermined. They found that the extra dimensions could actually be much larger than the Planck length, without anyone having noticed. If you suppose that the fundamental scale is not the Planck length but rather the scale at which the weak force acts – changing one type of quark into another – then the extra dimensions could be as large as a millimetre.

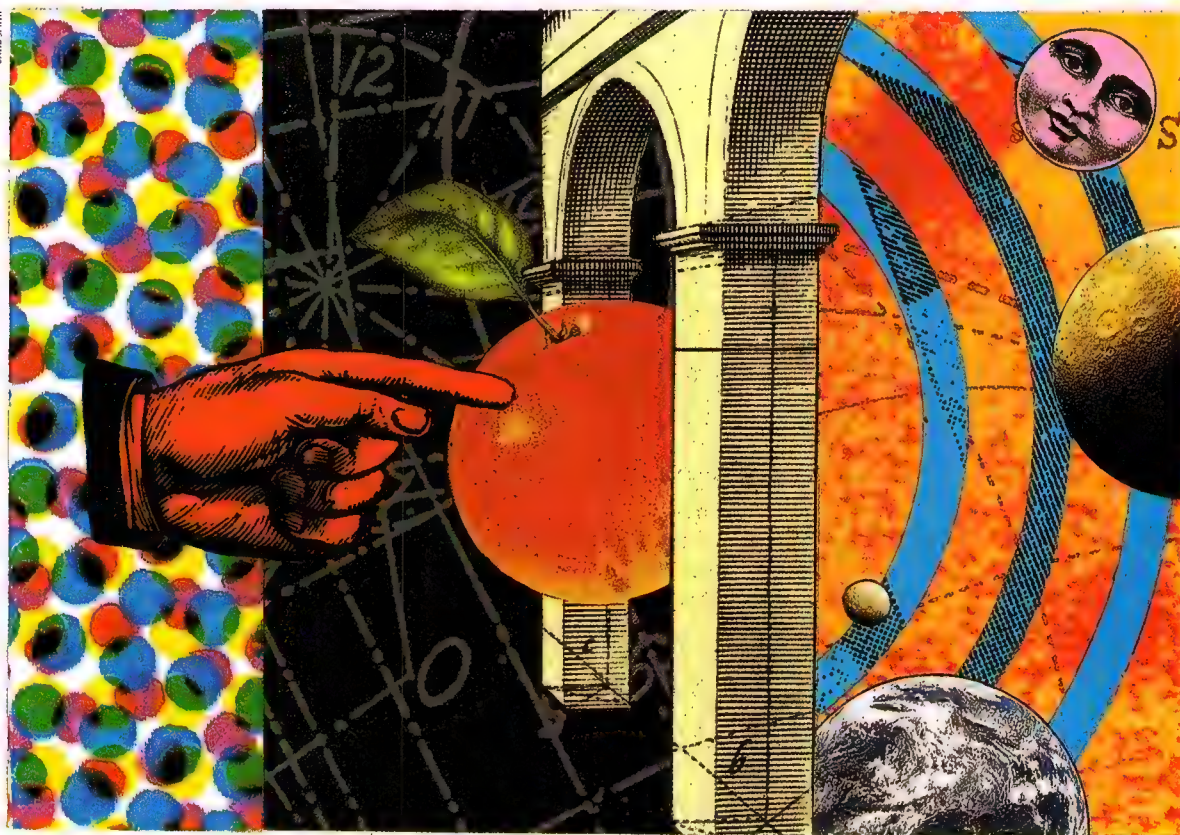
It sounded absurd. Surely such large extra dimensions would have shown up in astronomical or cosmological observations? Apparently not. The team searched the literature and could find no experimental result or phenomenon that depended on gravitational attraction at very small scales. Though they tried to kill off their theory in every way they could think of, they failed. "It survived and was consistent with all the experimental results we could imagine," said Arkani-Hamed.

So these extra dimensions might be accessible to experiments after all. But that's not to say they would be easy experiments to perform: gravity is so weak that it is extremely difficult to bring together enough matter to generate a measurable force at a few millimetres of separation. After all, you can't play around with things the mass of a planet in an Earth-bound laboratory. Nonetheless, Adelberger and his colleagues have slowly and surely been finding ways to put an upper bound on the size of the hidden extra dimensions. ►

The mystery of disappearing gravity seems to be leading us to a higher plane.

Bruce Schechter follows the trail

Enlightenment



“The gravitational field in the lab had changed. The pull of water in the rain-soaked earth was enough to upset the calibration”

For this they are standing on the shoulders of giants. The method used by Adelberger's team owes much to the way Henry Cavendish first measured the strength of gravity in 1798. Cavendish used a torsion balance, a pair of weights arranged at the ends of a rod like a dumb-bell, and suspended in the middle by a thin wire. When he brought a test mass close to one of these weights, the gravitational attraction caused the bar to turn slightly, twisting the fibre. A mirror mounted on the wire reflected a beam of light, and by observing the motion of the reflected spot, Cavendish could measure the twisting of the wire and calculate the magnitude of the force.

Adelberger's experiment, allowing for two centuries of technological improvement, is pretty much the same. Like Cavendish, Adelberger and his colleagues suspend their apparatus from a wire. In their case the apparatus consists of a pendulum with 10 vertical holes bored symmetrically around the circumference of its base (see Diagram). Immediately below this pendulum are two metal discs called attractors, one above the other, which can be rotated. The attractors also have 10 holes drilled through them, but the holes in the thicker, lower disc are slightly larger, and are offset so that they lie

halfway between the holes in the upper disc.

To look for gravitational anomalies, Adelberger simply sets the attractors rotating together. The rotation of the thin upper attractor alone would cause the pendulum to twist back and forth 10 times per rotation (each twist is around one ten-thousandth of a degree). That's because the holes in the plates and the pendulum act, mathematically, like negative masses, which you can think of as attracting each other. However, the rotation of the lower, thicker attractor – or rather its offset holes – compensates for this. “You can arrange things so the peak of the signal from one plate corresponds to the trough of the signal from the other, so they just cancel out,” Adelberger explains.

The result is that the pendulum should not twist at all, provided gravity follows an exact inverse square law. If, on the other hand, a component of the gravitational force from the lower disc decreases more rapidly with distance, its effect on the torsion balance will be negligible, since it is further away. The forces will no longer cancel exactly, and the pendulum will twist.

Adelberger and his colleagues have tested the idea at ever smaller separations between the pendulum and the attractor discs. So far

they have published confirmation that gravity obeys the inverse square law down to around 160 micrometres, which means that any extra dimensions must be curled up smaller than that (*Physical Review D*, vol 70, p 42004). As yet unpublished results, obtained using a torsion balance with 42 holes amongst other technical improvements, constrain the extra dimensions down to 70 micrometres.

Progress is slow and painful, though. As the distance decreases, the researchers are fighting ever more sensitive effects. Part of the problem is simply the weakness of the signal they are trying to detect. The apparatus must be isolated from any gravitational effect that might nudge the pendulum and twist the wire, swamping the signal from the apparatus itself. The experiments take place in a vacuum to avoid twist induced by collisions with air molecules. Electrostatic attractions might also twist the pendulum: the researchers have attempted to overcome this by coating their apparatus with gold, and by putting a thin sheet of copper foil between the pendulum and the attractors. They have to get rid of almost all vibrations using a highly efficient damping system, and they must even compensate for local variations in the Earth's gravitational field, which has thrown up its own difficulties.

One summer, one of Adelberger's students went to great lengths to measure gravitational variations caused by factors such as the surrounding hills and mountains, so she could compensate for them by strategically placing large masses around the laboratory. A few months later she checked her experiment again and found that the gravitational field in the lab was no longer uniform. It took a while for her to realise what had happened: Seattle rain.

The main difference between summer and winter in Washington state is that there's even more rain in the winter – a lot more. A quick calculation confirmed that the gravitational pull of the water in the rain-soaked earth was enough to upset her careful calibration. But all is not lost. Ultimately, the Washington team believe they can exclude subtle effects like this and explore distance scales of a few hundredths of a millimetre.

Torsion balances are not the only way forward. Groups at Stanford and the University of Colorado have constructed what amount to microscopic tuning forks made from single crystals of silicon. If you set one of these tuning fork vibrating and then bring a test mass up close to it, the gravitational attraction subtly changes the

pitch of the tuning fork, and this change reflects the strength of the force. But again, errors can creep in.

Aside from eliminating stray vibrations, the experimenters have to watch out for electromagnetic fields and other effects. Even the ghostly Casimir force, caused by pairs of particles and antiparticles that spontaneously pop into existence out of the "empty" space of the quantum vacuum, is far greater than the gravitational force and must be carefully accounted for. Preliminary measurements have still revealed no evidence of any deviation from the inverse square law down to the 10-micrometre scale.

Exotic merger

An even stranger test of gravitation is being carried out by a group at the National Institute of Standards and Technology at the University of Colorado, Boulder. Jeffery McGuirk and his colleagues are using one of the most exotic states of matter yet created by physicists. They cool a cloud of rubidium atoms to within a few billionths of a degree above absolute zero and watch them merge to form something that behaves like a single quantum object: a Bose-Einstein condensate.

"The reason we like Bose-Einstein condensates is that they are very small and very cold," McGuirk says. Very cold means that there is virtually no thermal vibration to obscure the force measurements. And very small means they are great for probing gravity at short distances.

In their experiment, McGuirk and his colleagues suspend a spherical drop of Bose-Einstein condensate in a magnetic field. The drop is about three thousandths of a millimetre in diameter, and contains roughly 100,000 atoms. Then they bring the condensate near a small glass test mass, which causes it to oscillate. "The condensate particles kind of roll back and forth like balls in a bucket," says McGuirk. By taking a series of pictures of the sloshing condensate they can determine the frequency of the oscillation. As with the tuning forks, this frequency depends on the gravity of the test mass.

There is a catch, however. At these scales the Casimir force is about a billion times as strong as gravity – or at least the version that follows Newton's inverse square law – giving a huge random noise effect. "The only experiments that are sensitive to Newtonian gravity take place on a longer distance scale," McGuirk says. "But that doesn't mean that these measurements can't say something about effects beyond Newtonian gravity."

At small enough distances, McGuirk reasons, the curled-up dimensions might create some kind of anomaly in the condensate's reaction to the test mass. There is also a chance that such experiments might reveal something about the fundamental nature of gravity – we still don't know whether there is a gravitational particle or "graviton", the equivalent of electromagnetic photons. At small scales, something exotic like this may create enough extra force to show up over the Casimir background noise.

As yet, McGuirk and his colleagues have not published any results. In fact, all the various efforts to measure gravity at short distances have so far only confirmed Newton's centuries-old leap of faith.

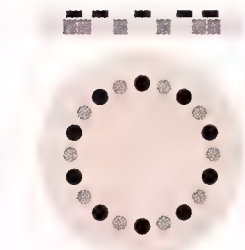
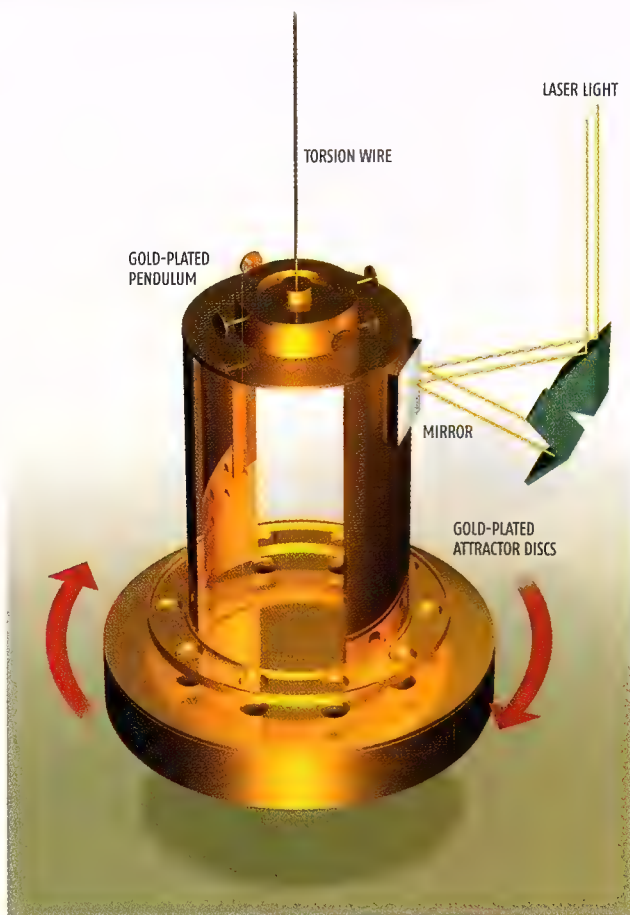
But nobody is disappointed, it seems. Though discovering new physics would be nice – Stockholm is a beautiful city to visit – Adelberger and all the others in this field are happy whatever the results. "We've extended the regime where we know what nature is doing substantially," Adelberger says. "It would be wonderful if you actually had a stunning new discovery. But even if nature doesn't roll its dice that way, you've still done a lot." ●

Bruce Schechter is a freelance writer living in Brooklyn, New York

HOW TO SEARCH FOR HIDDEN DIMENSIONS

This torsion balance might expose whether gravity is leaking into extra dimensions that have never been observed

The two attractor discs are set rotating. The way holes in these discs are offset means that their combined gravitational pull on the pendulum should cancel out, leaving the pendulum's torsion wire untwisted



As the gap between the attractors and the pendulum is reduced, any anomaly in gravity at small distances would cause the pendulum to rotate, changing the direction of the laser light bounced off the pendulum mirror. This would be evidence of hidden dimensions

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Applicants should send a full curriculum vitae (including key publications), a detailed research plan, a statement of teaching interest, sample and a list of names of at least three references to:

Prof. Raj Rajagopalan, Head of Department
(Attention: Ms. Nancy Chia)
Dept of Chemical & Biomolecular Engineering
National University of Singapore,
4 Engineering Drive 4,
Blk E5 #02-09 Singapore 117576
Email: checls@nus.edu.sg

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Nanyang
Technological University

Lee Kuan Yew Postdoctoral Fellowship

Applications are invited from young candidates who have obtained their degrees in the last few years with excellent academic records and have research potential for this prestigious research fellowship in the Engineering Schools, School of Biological Sciences and Natural Sciences.

For information on the Fellowship and the research areas, please visit the website: <http://www.ntu.edu.sg/personnel/adminres/StaffRec/AdLKY2005.html>. Interested candidates should send their application using the NTU application form together with detailed curriculum vitae, copies of the educational certificates, 3 international referee reports (including contact details), statement of research intent, list of publications to:

Vice President (HUMAN RESOURCES)
Office of Human Resources
Administration Building, Level 4
NANYANG TECHNOLOGICAL UNIVERSITY
50 Nanyang Avenue, Singapore 639798
Telefax: (65) 67919340
Email: LKLIM@ntu.edu.sg

Closing Date: 31 March 2005

Only shortlisted candidates will be notified.

CSIRO Sustainable Ecosystems and
the Weeds CRC, North Queensland



Post Doctoral Fellow – Weed Ecology

\$58k - \$64k pa plus Superannuation

Ref: 2005/72



The CRC for Australian Weed Management (Weeds CRC) brings together research and extension groups from universities, government agencies and industry. It is one of 71 Centres funded by the Australian Government's CRC Programme. The CRC for Australian Weed Management is at the forefront of the response to Australia's \$4b/yr weed problem.

We are seeking a highly motivated plant ecologist to conduct research addressing the ecology and spread of weeds in tropical rainforest ecosystems. This research will include theoretical and field components and will be focused on informing and improving the management of weeds in these ecosystems in Australia and abroad.

You will join a team of multi-disciplinary scientists who conduct research into tropical ecosystem dynamics and you will be an active member of the Weeds CRC. You will have excellent communication skills and a willingness to interact with community, industry and government stakeholders. The successful candidate should have excellent organisational and analytical skills and a PhD in theoretical or applied aspects of plant or weed ecology.

This position is funded by the Weeds CRC until December 2007 and located with CSIRO Sustainable Ecosystems' Tropical Landscapes Program based in Atherton or Townsville.

For further information about the Weeds CRC refer to www.weeds.crc.org.au

For selection documentation and details on how to apply visit

www.csiro.au/careers

Alternatively contact 1300 301 509

Australian Science, Australia's Future



Australian Government
Australian Transport Safety Bureau

Aviation Safety Research Grants Programme 2005/6

Invitation for Applications

The Australian Transport Safety Bureau invites applications from suitably qualified individuals and organisations to conduct research into aviation safety particularly as it applies to the Australian civil aviation context.

It would be an advantage for applicants to have experience in an area related to aviation safety such as aircraft/airline operations, human factors, engineering, the aviation industry, etc. Experience in developing and implementing research proposals will be well regarded.

The programme complements the ATSB's targeted research programme into current and emerging safety issues, and it is expected to encourage researchers from a broad range of disciplines.

Information about the programme and application kits can be obtained from the ATSB website at
www.atsb.gov.au/aviation/research/grants.cfm

The contact for technical aspects of the programme is Joy Sutton on (02) 6274 7133.

The application period closes at 5 pm on Friday 25 February 2005.

Ref. no. ASRGP0501



Café Scientific events take place throughout Australia in relaxed café and pub environments where scientists, experts and non-experts alike throw around ideas and raise questions about scientific issues.



Find out more at www.cafescientific.com.au
Website of upcoming events

Experimental and Computational Scientist

Fluid Dynamics

Our nuclear analysis group provides high level analysis, research and development, and expert advice in the areas of neutron transport, thermal-hydraulics, criticality safety and shielding. We work in a collaborative manner with a high degree of knowledge sharing and contribution to problem solving within the group. Your role will be to perform CFD analyses and carry out fluid dynamics experiments to validate the results.

You will have:

- a relevant science or engineering degree with Honours or higher (such as physics, mathematics or mechanical engineering)
- specialist experience in numerical and physical modelling in the areas of fluid dynamics, and heat and mass transfer.
- experience in data collection and interpretation for model validation and practical problem solving skills in mechanics and electronics.

Specialist nuclear training and experience in nuclear reactor fluid dynamics will be an advantage.

Starting salary will be negotiated between \$47K - \$53K depending upon qualifications and experience.

Selection criteria, application details and further information is available online at <http://www.ansto.gov.au> or by contacting Ms Robyn Thorburn on (02) 9717 9180 or by e-mail: robyn.thorburn@ansto.gov.au

Applications must address the selection criteria and close on **4 March 2005**.

Application Details: Please forward your application and resume to Ms Robyn Thorburn, Reactor Operations, ANSTO, PMB 1, Menai, NSW, 2234 or e-mail: robyn.thorburn@ansto.gov.au



Australian Government

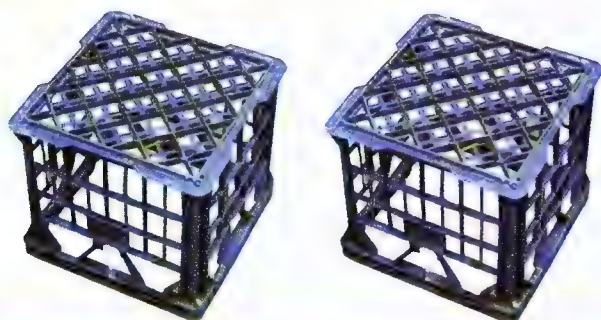
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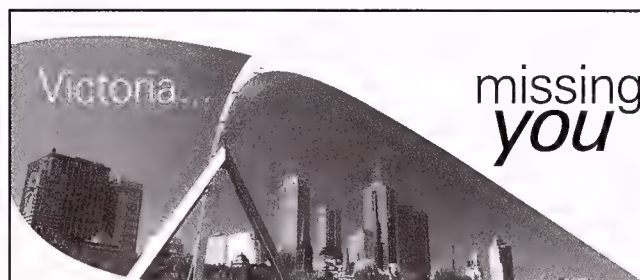
NewScientist Jobs

Casual Mathematician

Quantum-infinity theory

Who can help me with mathematics/physics and infinity and big bang calculations. My quantum-infinity theory states that the smallest possible spacial separation of events is the Planck length and therefore 1 mm can contain only 6.25×10^{32} events and 1 mm² only 3.9×10^{63} events.

Please forward your interest to
Dr. Hans Klieber
bio@biosydney.com



VESKI (Victorian Endowment for Science, Knowledge & Innovation) brings the best minds and talents back home, where they belong...Australia, and more specifically, Victoria.

If you are an expatriate Australian with an outstanding record of achievement in Science, Technology or Design, incentives to return to Victoria – the hub of Australia's bio-research industry and its leading centre for Design – have never been better. Meet our criteria for excellence and you may be eligible for a *VESKI Victorian Innovation Fellowship*, qualifying you for a research grant of up to AUD\$100,000pa against matching funding.

Victoria today offers world class opportunities. With eight top universities, seven major teaching hospitals, 22 medical research institutes and over 200 bio-technology firms, ICT research centres of excellence as well as the coveted title of The World's Most Liveable City*, it truly is *the place to be*.

veski Victorian Endowment for Science, Knowledge & Innovation

Further information and application details at www.veski.com.au

Applications close 28th February, 2005

*Economist Intelligence Unit (London)



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SARDI



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INSTITUTE

The South Australian Research and Development Institute (SARDI) is renowned for its innovation in the food, fibre and bioscience industries and in living environmental systems. SARDI transfers its knowledge, technologies, products and services through scientific exchange, extension and commercial arrangements.

SARDI's headquarters are attractively located at the Waite research precinct in the Adelaide foothills just 7 kms from the city centre.

This significant role provides leadership to SARDI's research and development, supporting the Executive Director in strategic and operational management. The scientific leadership is provided across the key disciplines of Aquatic Sciences, Crops, Livestock, Horticulture and Sustainable Systems.

You will be a senior research manager with impressive scientific credentials and a national/international reputation. You will also be a strong leader and motivator and have strategic focus and business and commercialisation acumen. Innovative and creative, you will have the ability to develop collaborative relationships across a variety of industry sectors and research institutions.

For a position description and further information please visit www.hender.com.au

Applications should be forwarded to Sacha Ure by e-mail to 24489@hender.com.au **Telephone enquiries may be directed to Gill Manser on** +61 8 8100 8825.

E29987



A member of the Consultative Group on International Agricultural Research (CGIAR), the WorldFish Center (Formerly known as ICLARM) is an international scientific research organization conducting fisheries and aquaculture research in tropical developing countries, with global headquarters in Penang, Malaysia.

POST DOCTORAL FELLOW - GENETIC IMPROVEMENT

Duties and Responsibilities:

- Design, implement and maintain the system of data capture, storage, retrieval and analysis for the genetic enhancement projects;
- Assist in the development of research proposals in the area of genetic enhancement and in other areas;
- Prepare publications at the scientific, extension and popular press level;
- Prepare and make presentations on projects' outline and results;
- Interface and coordinate activities with counterpart staff from partner organizations and countries prior to and during project implementation.

Requirements:

- PhD within the past 5 years in relevant field;
- Excellent communication skills in written and spoken English;
- Competence in data base development and maintenance, programming and use of SAS (Statistical Analysis System) and experience with ASREML, DFREML, VCE and PEST.

For a detailed position description or to apply, please visit Center's website: <http://www.worldfishcenter.org>
or email to worldfish-hr@cgiar.org
Closing date for applications is 27 February 2005

CHIEF EXECUTIVE

- Sarawak Biodiversity Centre
- Kuching, Sarawak (Malaysia)
- Expatriate Benefits

The Sarawak Biodiversity Centre (SBC) is the focal point for Sarawak biodiversity inventory, monitoring, research, education, utilisation, management and conservation. With strong support from the Sarawak Government as a Centre of Excellence, SBC's main business activities are to implement bio prospecting and R&D programmes; conduct biodiversity-biotechnology appreciation and awareness programmes; implement the Regulatory Function; regulate biodiversity related research in Sarawak; document traditional knowledge on communities' use of biodiversity; propagate Sarawak's indigenous plants for conservation and appreciation; maintain biodiversity related databases; and network nationally and internationally.

The CEO is responsible to the Chairman of the Sarawak Biodiversity Council for formulating plans and policies and implementing strategies for SBC; ensuring the smooth running of SBC activities; and developing and commercialising new products with or without collaboration with other R&D agencies and pharmaceutical companies.

This challenging position offers a rare opportunity to work in one of the world's premier biodiversity environments and to lead SBC in its biodiversity R&D and commercialisation programmes. You should have in-depth knowledge of biodiversity management and commercialisation; experience working with scientific and research teams; excellent interpersonal, leadership and organisational skills; a high level of personal integrity and commitment; and excellent connections with relevant R&D and pharmaceutical organisations.

Please forward details, email preferred, quoting Reference No. 50104 to Richard Ogilvie, Ogilvie Watson, Level 7, 1 Collins Street, Melbourne, Vic. 3000.

Email: richard@fnow.com.au
Tel: (03) 9654 7750

Web: www.ogilviewatson.com.au
Fax: (03) 9654 5825

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**BIOSECURITY
NEW ZEALAND**

Senior Adviser, Nursery Stock (Import Health Standards)

**Vacancy
number:
05/05**

This position is within the Import Health Standards Team in Biosecurity New Zealand, Ministry of Agriculture and Forestry (MAF), Wellington, New Zealand.

The Senior Adviser is responsible for:

- Development, review and implementation of import health standards for nursery stock commodities (plant and forestry species) including leadership of project teams. This also includes representing MAF in discussions with international bodies and government agencies;
- Development of technical and operational standards (importation and clearance of plant propagation material).

The Senior Adviser will be involved in technical quarantine discussions with appropriate authorities in overseas countries and the audit of programmes in New Zealand for the importation and clearance of nursery stock.

For this role you will require:

- A degree in a plant related science preferably in plant pathology, or relevant experience;
- Good oral and written communication skills;
- Ability to plan, set priorities and meet deadlines within tight time frames;
- Ability to work under stress and in conflict situations created by high work loads, changing priorities, and industry and political demands;
- Proven ability to work with others in a team environment.

Preference will be given to applicants with experience and knowledge of quarantine principles, horticultural production systems, agrochemical treatments and biometrics.

A full position description and an application form are available on the MAF Web Site <http://www.maf.govt.nz> (click "Employment at MAF") or obtain copies from Esther Maxim – address below.

For more information on technical and professional details contact:

Gerard Clover
Team Manager, Operational Standards
Tel: 64 4 470-2743
Fax: 64 4 498-9888
Email: gerard.clover@maf.govt.nz

Send your application (with CV), quoting vacancy number 05/05, to:

Esther Maxim
MAF Biosecurity New Zealand
PO Box 2526
Wellington
NEW ZEALAND
Tel: 64 4 498-9843
Fax: 64 4 498-9888
Email: esther.maxim@maf.govt.nz

Applicants must hold (or be willing to obtain) a current New Zealand work permit or be a New Zealand resident.

The Ministry of Agriculture and Forestry is committed to equal employment opportunities.



Café Scientific events take place throughout Australia in relaxed café and pub environments where scientists, experts and non experts alike throw around ideas and raise questions about scientific issues.



Go on to
www.cafescientific.com.au
for details on upcoming events



Chief, Textile & Fibre Technology

CSIRO Technology & Fibre Technology, Geelong VIC
Substantial Package

The Commonwealth Scientific & Industrial Research Organisation is one of the world's largest and most successful R&D institutions. CSIRO is committed to complementing its world-class science capabilities with a successful largescale external focus and commercial ability. The position of Chief is the key line leadership role in CSIRO's structure. The position of Chief at the Textile & Fibre Technology Division will become vacant in July 2005. The Division seeks a visionary leader who will become a central figure in the new CSIRO, with a mix of outstanding leadership and science skills, and an outward-looking commercial approach.

The Role

- Responsible for the scientific leadership and management of a team of 180 and a budget around A\$24 million, of which half is derived from external funding.
- Stimulate and champion areas of science and technology in response to research opportunities and customer and stakeholder priorities and thus generate Intellectual Property and deliver successful research outcomes.
- Build strategic and collaborative relationships, meeting CSIRO and national priorities for growth and excellence in science and technology.

The Qualifications

- A renowned research leader/motivator with a sound appreciation of the operation and needs of Australia's Wool, Cotton and Textile industries.
- Successful track record in leading and delivering high quality strategic and applied science.
- Strong influencing and relationship building skills at the top levels of industry and government.
- Commitment to growth, results and people, with a collaborative style and seasoned commercial and management skills.

Ref: 2005/123 For a comprehensive selection package and to apply visit www.csiro.au/careers - alternatively please contact John Baistow +61 2 9490 8253

L141/082

CSIRO ICT Centre

Research Scientist/ Engineer - Machine Learning

5 Year Position

\$92K - \$119K + Superannuation

Ref: 2004/1576

The CSIRO ICT Centre is seeking a highly motivated and experienced senior scientist to lead a team working in the area of intelligent systems, in particular machine learning and networked or multi-agent systems.

A major focus of our research is in distributed intelligent sensing and communications systems, examples include power distribution networks, a self-monitoring/repairing skin for aerospace vehicles, sensor and actuator networks and robots. Such problems may be represented as multi-agent systems, for which our goal is the determination of agent properties to achieve desired system behaviour. The development of new machine learning methods for agents within such networks is a significant part of the research.

The successful candidate will lead the main research projects in this area within the ICT Centre, formulate research directions in consultation with the Autonomous Systems research leader and direct and supervise the staff of the project. He/she will also be expected to develop a significant scientific profile for the group's work locally and internationally and to actively engage with industry. Collaboration with other CSIRO research groups and Universities is essential.

The position will require a Ph.D. in Computer Science, Electrical Engineering or equivalent discipline, focused on an intelligent systems topic, and a significant international reputation including a substantial publication record in this field coupled with a demonstrated ability to apply research to solve a significant problem.



For selection documentation and details on how to apply visit

www.csiro.au/careers

Alternatively contact 1300 301 509

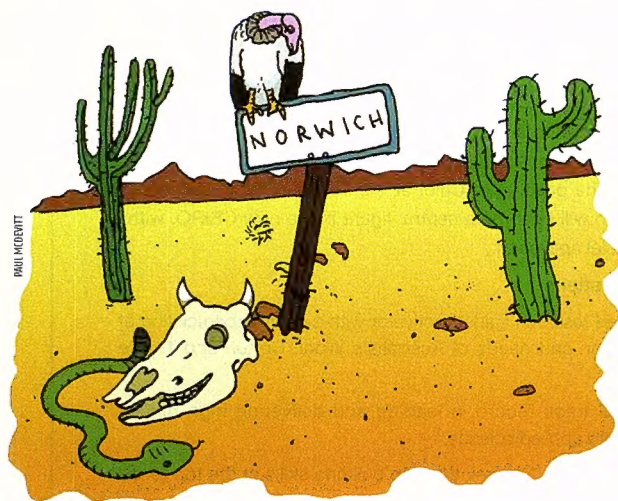
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Café Scientific events take place throughout Australia in relaxed café and pub environments where scientists, experts and non experts alike throw around ideas and raise questions about scientific issues.



visit
www.cafescientific.com.au
for upcoming events



THE county of Norfolk in eastern England is noted, in Noel Coward's words, for being "very flat". But could it really be the hottest place in the world too? When James Brown tried out Microsoft's new search engine, MSN Search, earlier this month, he was intrigued by the claim that by using information in Microsoft's Encarta encyclopedia it could answer questions as well as search by keywords. So, after confirming that the normal human body temperature is 37 °C and that Ouagadougou is still the capital of Burkina Faso, he asked it to tell him the "hottest place in the world".

The first item <http://msn.co.uk> gave him in response to this was another world, "Venus (planet)". This was followed by two plants, "pomegranate" and "camellia", and then a genus of birds, "*Anhinga*". The fifth item was finally something that actually was a place and was in this world: "Norfolk (county, England)". "Norfolk," it went on to explain helpfully, "is particularly famous for turkey and geese."

Brown, who happens to live in Norfolk, acknowledges that the winter has been very mild and the daffodils are

coming out unusually early this year, but is thinking that perhaps he should replant his garden with sagebrush and cactus. And he looks forward to camels grazing in the field next to his house instead of the geese for which Norfolk is indeed famous – about the only thing that MSN Search got right.

WE have believed for some time now that the music industry has been wasting its time and money on the new "super hi-fi" disc systems DVD-Audio and Super Audio CD. However good they may be, most music lovers are perfectly happy with the already super sound of CD and ordinary DVD. And the record companies have hardly done themselves any favours by promoting the new discs as being harder to copy.

So it was with special pleasure that we read a press release from Japanese hi-fi company Denon: "The Denon DVD-1910 DVD Player eschews SACD & DVD-A," writes the company's spokesman. "In a practical move designed to benefit the average user, the 1910 deliberately does NOT have unnecessary SACD or DVD-A circuitry. These formats are being totally ignored by general consumers and at this price point their inclusion is a waste of time and money."

BACK in the 25 December 2004 issue, we reported on Mark Hodson's belief that he had come across the only example of a recursive malapropism, when a colleague who found herself supernumerary to a task commented "I think I'm erroneous here" – which she wasn't until she said it, but then she was, so she wasn't.

Nobody has yet been able to supply another example of this that meets the full criteria, but we still like the one sent in by Mark Appleby, even though no malapropism is involved. His partner, he says, complaining about their vacuum cleaner's woefully limited ability to pick up dust, commented, "This vacuum cleaner really sucks." Which, Appleby points out, it did, because it didn't. So it did.

EMAILS with truncated subject lines continue to bemuse readers. Peter Bleackley got one saying: "Fluconazole is an azole antifungal used to treat or prevent fun." Could this be useful for puritans with athlete's foot, he wondered. Meanwhile, Tom Baring wondered if the spammers had turned soft when he received one saying: "Have you ever wanted to impress your girl with a

hug..." He realised they hadn't when he read the rest of the subject line, but we'll leave it to you to guess what that said.

JOHN Wooller had to ring his bank to give his new address. When he got through, he was treated by way of on-hold music to a Ronan Keating song with a chorus that goes: "You say it best when you say nothing at all." Whereupon the line went dead before he had been connected to anybody. Just a coincidence, of course.



DUNCAN Simpson is amazed at what you can find on Amazon.com these days – like packs of 12,000 eggs of the parasitic *Trichogramma pretiosum* wasp for biological control of garden pests: "*Trichogramma* wasps are tiny parasites that attack the eggs of over 200 species of moths and caterpillars," Amazon explains. "They are extremely small."

Along with this surprising product Amazon gives us some surprising comments from customer reviewers, including a recipe for a *T. pretiosum* omelette. It begins: "Carefully crack 12,000 *Trichogramma pretiosum* eggs into pan over medium heat..." Apparently, 19 out of 28 people who read this review found it "useful".

FINALLY, the walls of London's underground stations were plastered not so long ago with ads for a horror movie declaring, "Thirteen ghosts. Terror has multiplied." Greg Roughan tells us how much he regrets not decorating them with graffiti saying: "Multiplied by what, dumb-ass? Thirteen is a prime number."

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

If you do a Google search for "free CDs", one of the results that appears is an advertisement that reads: "Free CDs. Huge selection of free CDs in stock at discount prices!"

The last word

Last Words past and present, plus a full list of unanswered questions, are available on New Scientist's website at www.newscientist.com

CLOUD COVER

A group of cumulus clouds was passing over my house in Tuscany, Italy, on a September afternoon lit by the low sun at about 5 pm. A clear shadow of the lower clouds was appearing on the undersurface of the upper clouds. Given that the light came from above both sets of clouds, how was the shadow projected on the higher ones?

We received lots of theories for this phenomenon, but no single conclusive idea – Ed

● I took the photograph (below) last August at about 5 pm. The sun did not set for another 3 or 4 hours. Like your correspondent, I was mystified by the apparent shadow cast above, rather than below the cloud. This puzzlement was compounded by the rays of sunlight visible against the shadow. *Jeanette Stafford Glasgow, UK*



the short bright edge on this cloud. The light is strongly reflected and scattered, illuminating a large area of the underside of the middle layer, as the picture shows. This cloud, in turn, casts a shadow on the upper stratus cloud.

Chris Daniel Kingston upon Thames, Surrey, UK

● The sun is at a low angle, close to sunset, so it is illuminating the clouds from underneath. Shadows from the cumulus are being cast upward, resulting in this unusual display of light and shadow.

Rachel Vis Melbourne, Australia

● The shadow is not being projected onto the higher clouds, but rather onto the air between the cumulus clouds and the camera. I have seen similar shadows just before dusk caused by planes, which showed up as dark streaks. The scattered light makes the air appear to glow, except in the areas where it is being shaded by the clouds.

Bob Mitchell Niceville, Florida, US



● The original photograph sent by the questioner (above right) contains most of the clues to what is going on here.

There are three layers of cloud in the picture: an upper broken stratus and two lower cumulus layers. The sunlight, which seems to be coming from the lower middle of the picture, is falling onto all the cloud layers, including a small part of the lowest cumulus cloud. This can be seen by

ACID INDIGESTION

Where do chloride ions in stomach acid come from?

● They come from good old common salt, sodium chloride. Doctors will often advise those with chronic heartburn problems to limit their consumption of salt because this in turn will limit the amount of stomach acid produced.

Bill Barnes Warrington, Pennsylvania, US

● The chloride ions that produce stomach acid originate in blood plasma. Our plasma contains a range of salts: the positive ions are mostly sodium and the negative ions are mostly chloride.

The production of stomach acid is powered by pumps within the membrane of specialised stomach cells called the gastric parietal cells. These pumps force hydrogen ions from within the cells out into the stomach, exchanging them for potassium ions and consuming energy in the process.

Within the parietal cells, the supply of hydrogen ions is replenished by the reaction of carbon dioxide with water. The cells contain the enzyme carbonic anhydrase, which catalyses this reaction. The reaction also produces bicarbonate ions, which leave the cell for the plasma via a channel that exchanges them for chloride ions, which diffuse out into the stomach.

The net effect is that the plasma loses carbon dioxide, water and chloride ions and gains bicarbonate ions, while the stomach contents gain hydrochloric acid. Interestingly, this means that when the stomach is metabolically active it consumes carbon dioxide, unlike most organs of the body, which are net producers of carbon dioxide.

Tim McCulloch Department of Anaesthetics Royal Prince Alfred Hospital Camperdown, New South Wales, Australia

THIS WEEK'S QUESTIONS

Nostalgic nasturtiums?

I am in my late sixties and am increasingly reminded of the importance of memory for everyday living. I believe that most animals, even quite lowly ones, are able to remember things, but can plants?

John Salaman Cardiff, UK

Beating the bell

Awakening a minute or so before the alarm is a common experience and I, like many people, have learned the trick of setting such an "internal alarm". Biochemical clocks and circadian rhythms hardly seem to explain how a mental clock could be so accurate. What is happening?

Larry Constantine Rowley, Massachusetts, US

Questions and answers should be kept as concise as possible. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and a fax if you have one. Questions should be restricted to scientific enquiries about everyday phenomena. The writers of all

answers that are published will receive a cheque for £25 (US\$40, or the sterling equivalent in local currency). Reed Business Information Ltd reserves all rights to reuse question and answer material submitted by readers in any medium or format.

Send questions and answers to The Last

Word, New Scientist, Lacon House, 84 Theobald's Road, London WC1X 8NS, UK (fax +44 (0) 20 7611 1280) or by email to lastword@newscientist.com (all correspondents should include their postal address in order to receive payment for answers). If you would like a complete list of

all unanswered questions please send an SAE to LWQlist at the above address.

Two books containing many of the best questions and answers from 10 years of The Last Word are now available from all good book stores and are published in a number of languages.

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